WEATHER MODIFICATION

OF MICHIGAN
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MAIN READING ROOM

HEARING

BEFORE THE

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WEATHER MODIFICATION

MONDAY, FEBRUARY 16, 1959

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10 a.m., in the caucus room, Old House Office Building, Hon. Overton Brooks (chairman) presiding.

Witnesses: Dr. Ruben Gustavson, president, Resources for the Future, Ford Foundation; and Chairman, NSF Advisory Group on Weather Modification; Dr. Robert Brode, Associate Director, Research, National Science Foundation; and Dr. Earl Droessler, Program Director for Atmospheric Sciences, National Science Foundation.

The CHAIRMAN. The committee will please come to order.

It is our policy to proceed on time, regardless. Some of these witnesses come from distant points, and it is unfair to invite them here and not have your meetings begin on time, so that they can finish and get away. As a result of it, we are going to begin on time.

On Monday morning it is a little difficult to get the members in, but they will be in, and we will tally them as present.

This morning we have a number of witnesses in reference to weather. That is going to be the subject of our investigation this morning.

We have as the first witness this morning Dr. Ruben Gustavson, president, Resources for the Future, Ford Foundation; and chairman, NSF Advisory Group on Weather Modification.

Doctor, we are very happy to have you.

Now, you have others with you; is that Dr. Brode?

Dr. GUSTAVSON. Yes, Mr. Chairman. Dr. Brode will make the opening statement.

The CHAIRMAN. Dr. Brode is Associate Director, Research, National Science Foundation.

And also here is Dr. Earl Droessler, Program Director for Atmospheric Sciences, National Science Foundation.

Mr. ANFUSO. Do we have a printed statement?

The CHAIRMAN. Yes, that is what we are going to get to.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Now, Dr. Brode has a mimeographed statement for the committee.

Doctor, do you have a statement that you want to make?

Dr. BRODE. Yes.

Mr. MILLER. Mr. Chairman, before you commence, may I say this about Dr. Brode:

He was formerly connected with the University of California and comes to Washington in line with a number of distinguished scientists

from the University of California who have made a great contribution to this country in the advancement of the defense of this country.

I have in mind such men as Dr. Lawrence, Dr. Oppenheimer, and Dr. Teller, all of whom were connected with nuclear physics, and I am very proud to see Dr. Brode here now following another line of science and coming from that great educational institution.

Thank you, sir.

The CHAIRMAN. We are happy to have you, Doctor. And, of course, all of these Californians are very modest. I am sure you follow the rule in that respect. But we do know of you and are certainly happy to have you this morning.

Dr. BRODE. Thank you.

Mr. Chairman, members of the committee, I might just enlarge upon my friend, Mr. Miller's remarks that Herb York, whom I think you will hear tomorrow, is another one of the University of California men who are taking over Washington.

Mr. MILLER. Who will be here?

Dr. BRODE. Dr. York.

Mr. MILLER. Oh, yes.

The CHAIRMAN. Mr. Miller will be here tomorrow.

Mr. TEAGUE. I am glad the Democrats are taking over California. California may take over Washington.

The CHAIRMAN. Dr. Brode, you have a prepared statement, and I believe all of the members have a copy of it.

Dr. BRODE. Yes; I have a brief statement which I believe the members have been given.

STATEMENT OF DR. ROBERT BRODE, ASSOCIATE DIRECTOR, RESEARCH, NATIONAL SCIENCE FOUNDATION

Mr. Chairman, the National Science Foundation appreciates very much the opportunity to appear before this committee, and Dr. Alan Waterman, the Director of the National Science Foundation, asked me to express his sincere regrets that he is not able to be here this morning, having previously been called before another committee of the House, which is meeting at exactly this time on the budget of the National Science Foundation, and so he will be unable to be here.

The weather modification program of the National Science Foundation——

The CHAIRMAN. Pardon the interruption, but I am sure Dr. Waterman must understand the rules of the House of Representatives, this committee has jurisdiction over the work of the National Science Foundation.

Dr. BRODE. Yes; he is very well aware of that, but he had previously accepted the request of Mr. Thomas to appear before the Appropriations Independent Agencies Committee this morning, which he is now speaking to.

Mr. MILLER. You are very politic when you say he had accepted the request of Mr. Thomas to appear over there. We understand.

Dr. BRODE. The weather modification program of the National Science Foundation dates from July 11, 1958, when Public Law 85–510 was signed by the President.

The law directs the Foundation—

to initiate and support a program of study, research, and evaluation in the field of weather modification * * *.

Public Law 510 was a direct outgrowth of the work of the Advisory Committee on Weather Control, which committee was established by Congress in 1953.

For 4 years the advisory committee studied and evaluated public and private cloud-seeding experiments and encouraged programs aimed at developing both physical and statistical evaluation methods. The final report of the committee was issued in December 1957. It is a 2-volume report which for the first time placed before the American public a body of available facts and a variety of views on the status of the science of cloud physics and the techniques and practices of cloud seeding and weather modification.

The statistical procedures employed by the committee indicated that the seeding of winter-type storm clouds in mountainous areas in Western United States produced an average increase in precipitation of 10 to 15 percent from the seeded storms with heavy odds that this increase was not the result of natural variations in the amount of rainfall. However, in flatland areas, the same statistical procedures did not detect any increase in precipitation that could be attributed to cloud seeding. The report particularly stressed the importance of basic research and recommended that the Government give full encouragement and support to the widest possible research as the surest and most direct way to success in any attempt at modifying the weather.

In the years just prior to Public Law 510, the National Science Foundation funded a modest program in cloud physics which provided support for a broad range of research on important problems. Laboratory studies of cloud-seeding materials were carried out at the University of Chicago. The same university developed an airborne instrument for measuring the water content of clouds, and the Northam Electronics, Inc., studied automatic counters for freezing nuclei. Partial support was given to statistically controlled cloud-seeding field experiments in Arizona (the University of Chicago and University of Arizona), and in Santa Barbara County, Calif. (University of California). Under other National Science Foundation grants, the University of Arizona compiled a census of cloud types observed over Southwestern United States, and the University of Utah conducted a statistical evaluation of the rainfall patterns in the Rocky Mountain region.

With the receipt of the new legislation, the Foundation moved promptly and vigorously into its new area of responsibility. A program of atmospheric sciences was established and weather modification research and evaluation was placed therein. A program director and professional assistant were appointed as staff. Following the usual pattern of foundation operation, the weather modification program will be administered principally through grants and contracts. A large buildup of internal staff is not foreseen.

Next, the Foundation sought the advice and assistance of outstanding scientists and engineers in framing its program; for weather modification is an area of research involving many talents and disciplines. It embodies knowledge of meteorology, statistics, mathematics, physics, chemistry, and engineering. Therefore, in October 1958, an

Advisory Group on Weather Modification of distinguished civilian experts was appointed by the Director of the Foundation. The chairman of the group, Dr. Reuben G. Gustavson, is with us this morning and he has a brief statement to make which will follow mine.

The advisory group has had two meetings to date. It has fashioned general and specific guidelines within which the program will be carried out. For example, in a report to the Director of the Foundation, dated February 4, 1959, the advisory group stated:

> Placing this important field of research under the aegis of the National Science Foundation has given rise to a new hope and confidence that the instability factors in regard to size and time of support will be removed. This is already bringing young imaginative workers into the field. The rate of advance will to a large measure depend upon the quality of the trained scientists attracted to the problem. If good scientists are to be attracted into the program, the Foundation must be particularly concerned about the financial stability of the program. Generally speaking, 3-year grants should represent the minimum period for starting new projects.

More recently, the Director of the Foundation invited the several interested Government agencies to appoint representatives to the Interdepartmental Committee on Weather Modification. This Committee was formed by the Foundation to keep the Government activities fully advised of the national efforts in this expanding area of meteorology, and to encourage coordination among the related programs of the several interested agencies. The response from the other Government agencies was prompt and gratifying. Full cooperation with the Foundation was assured. We look for the committee to insure a cohesive and effective U.S. program in which other Federal agencies are expected to participate by taking charge of projects suitable to their interests.

Dr. Earl G. Droessler was named Chairman of the Committee and the following Government departments are represented in addition to the Foundation:

Agriculture; Commerce; Defense; Army; Navy; Air Force; Health, Education, and Welfare; and Interior. The organizational meeting of the Committee was held on January 13, 1959. A full exchange of program and planning information was accomplished.

With respect to the weather modification program, itself, some highlights of accomplishment can be enumerated as follows:

1. To stimulate and initiate research and evaluation and to bring together cross-discipline scientific and engineering groups that must be involved in any program expansion, a series of three workshop conferences have been planned. The first, to be held in February 1959, is being arranged by the American Meteorological Society and the Foundation for Instrumentation Education and Research to study the problem of improved measurement and instrumentation for cloud physics and weather modification.

The second conference is planned for April 1959 under the auspices of the National Academy of Sciences and will bring together mathematicians, statisticians, and cloud physicists to exchange ideas on the design and evaluation of field test programs. And the third meeting will call meteorologists, physicists, and chemists together to discuss theoretical and experimental research regarding the scientific basis of weather modification. The meeting is being arranged by the American Geophysical Union.

2. The program has established direct contact with all known private weather engineers and consulting groups in the country. We have informed them of the new weather modification program and and have asked for their cooperation. We have sought their advice and assistance in the preparation of information forms which they will use in reporting all cloud-seeding operations to the Foundation. Cordial responses containing promises of full cooperation are beginning to reach the program.

3. The weather modification program has received to date 20 proposals for research support with a total budget request of over $3 million. These proposals are carefully screened and reviewed within the Foundation and some have been judged to be meritorious and worthy of financial support. Estimated expenditures may reach to $1.4 million in launching the program this fiscal year, distributed approximately as follows:

Laboratory studies, $400,000; experimental field projects, $180,000; physical and statistical evaluation, $150,000; conferences, $40,000.

Two million dollars in additional funds have been requested for fiscal year 1960. With this money an orderly program of long-term projects can be supported by Foundation grants and the scientists and engineers involved can proceed with their work.

Mr. Chairman, that concludes my prepared statement.

I would like to have Dr. Ruben Gustavson, the Chairman of the Advisory Group on Weather Modification, continue the Foundation's prepared report.

The CHAIRMAN. Dr. Gustavson.

Dr. GUSTAVSON. I would like to say just a few words.

The CHAIRMAN. Do you have a written statement?

STATEMENT OF DR. RUBEN GUSTAVSON, PRESIDENT, RESOURCES FOR THE FUTURE, FORD FOUNDATION, AND CHAIRMAN, NATIONAL SCIENCE FOUNDATION ADVISORY GROUP ON WEATHER MODIFICATION

Dr. GUSTAVSON. No; I do not.

The gist of what we have to present has been presented by Dr. Brode, but I think some philosophical background is helpful in approaching this problem.

We find in general in science that we frequently go along with an area where there is very little, if anything, exciting, and suddenly we get a breakthrough. Following the breakthrough there is frequently a tremendous effort, not too well organized, not too clearly thought out, which follows.

This then is followed by another period of what one might call insight. The basic problem that we are dealing with in rain production or precipitation of water, either in the form of snow or water, is of course just one phase of this big problem. Basically, this involves how do you get from 1 million to 8 million tiny cloud droplets to coalesce to make 1 drop of rain? This is the basic problem that you face.

We talked about weather, as Mark Twain said, but nobody did anything about it.

In 1946 you had this dramatic experiment of Schaeffer and Langmuir in showing the possibilities of producing precipitation. Then there rushed into the field some people, well trained, a lot of people attempting to get into a commercial venture, but at any rate, we had a lot of work done, and when you look at it all and try to evaluate it, it is very difficult to say whether you did or whether you didn't. It is something like correlating the crowing of the cock in the morning with the coming up of the sun. You would probably get a pretty high correlation, but it would be rather meaningless.

So now we are in the area of insight. We are studying the very basic scientific problems that are involved in getting these tiny droplets together, and I was interested in reading, sir, an article in the last issue of Science, by Houghton, of MIT, in which he reviews this whole problem. As you read it, you can not help but recognize that he raises one problem after another that needs solution, very basic problems, on size of particle, on distribution of the size of the particle, on the electrical conditions in the clouds——

The CHAIRMAN. Dr. Gustavson, let me interrupt you just a moment.

Can you gentlemen at the far end hear all right, and can you hear over there all right, Mr. Ducander?

Mr. DUCANDER. Yes.

Dr. GUSTAVSON. On the kind of nuclei that will be the basis of the precipitation, on the temperature of the cloud, and the relationship of the cloud to the underlying surface of the earth, and so forth.

Now, we find that when you have centers of interest started and supported, then you draw young people into the field. But when men find that a project gets started and then at the end of a year or 2 years it is dropped, young people drop out of the field.

For example, cancer research is very close to us. Here is a field of research in which there has also been a tremendous amount of confusion and some breakthrough, but with the solid support that the cancer work is now being given, a tremendous number of young people are being attracted into the field. Basic research is being done. We are beginning to understand the fundamental problems of cancerous growth, and we are going to get a breakthrough, I am sure.

This is the field of weather modification. It would be wonderful if we could sit before you this morning and tell you just exactly what is going to be done, but no one who has had any training in science would dare to do this. He wouldn't want to.

What we can do is outline in general the many unknowns in the problem, the basic problems that exist, and tell you that experience shows that when you get certain centers of high interest and accomplishment going, young people are attracted. If support comes, results come out. So we are pleading for a sustained program in order to support the highest type of work that will attract young, imaginative people into the field, and we feel that this field is a tremendously important one. In my organization, for example, I suppose we spend half of our money on the problem of the weather and the water problem from east to west in connection with large municipalities, recreation, river basins, industry. Water is one of the important factors that enters into it all, and it is for this reason that it is so important

and also for this reason that it is so important to get the right kind of workers into the field.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, sir.

Dr. Droessler, do you wish to make a statement?

STATEMENT OF DR. EARL DROESSLER, PROGRAM DIRECTOR FOR ATMOSPHERIC SCIENCES, NATIONAL SCIENCE FOUNDATION

Dr. DROESSLER. Yes, Mr. Chairman.

It is my job to direct the day-to-day activities of the weather program in the National Science Foundation. We in the Foundation believe the Congress has given us a fine opportunity to develop a sound and cohesive national program under the terms of Public Law 510. To do this we need the willing cooperation of the several Government agencies, the private professional meteorologists, and the scientists in our universities.

In our first 7 months of operation, all of these groups in turn have given us assurances and promises of full cooperation with the Foundation.

Through our Interdepartmental Committee on Weather Modification, which was established by the Foundation, we are bringing about a close working relationship among the various Government agencies, including the National Science Foundation, nine Government agencies are represented on the committee.

At our January 13 committee meeting a complete exchange of program and planning data was accomplished. We are very hopeful of conducting a coordinated national program which will avoid undesirable duplication and lead to an efficient expenditure of the funds that Congress makes available to this program.

For example, at our meeting we discussed the Army's project on the dissipation of supercooled stratus clouds; a Navy research program at the Woods Hole Oceanographic Institution, studying the large sea salt nuclei that are thought to be very important in the rain process in tropical clouds. We discussed also briefly the Air Force condensation trail suppression project. These are the small clouds that appear out of the exhaust of high-flying jets and give us information about cloud formation and dissipation in the higher reaches of the atmosphere. Also, the Weather Bureau's effort in supporting the Santa Barbara, Calif., seeding experiment.

None of the other Government agencies have plans for a broad systematic program of research and evaluation in weather modification, and all of them are looking to the National Science Foundation for leadership. We of the Foundation trust that we can meet this challenge.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Doctor. Now, Dr. Brode, I would like to ask you this: How does your work tie in with that of the Weather Bureau?

Dr. BRODE. As Dr. Droessler has just said, the representative of the Commerce Department is invited and is a member of our Interdepartmental Committee on Weather Modification. He is the Chief of the Weather Bureau, Dr. Reicheldoerfer; we adjust our program to co-

operate with him in our research work. The program as you have just been told is a program largely of grants-in-aid and support of research and we have made grants to a number of agencies and we have proposals from such agencies as the Weather Bureau for grants directed to it. As in connection with the International Geophysical Year operations, we make grants to the Weather Bureau for support of such work.

The CHAIRMAN. The Weather Bureau does do a certain amount of such support work here, scientific and experimental work, research and development type work.

Dr. BRODE. Yes; it does. Its primary duty and mission is that of the collection of the regular day to day weather synoptic observations and continuing data which is useful and necessary for research work to be done.

The CHAIRMAN. But you make certain grants to the Weather Bureau for specific time work.

Dr. BRODE. We have. I think Dr. Droessler can probably amplify that a little bit as to the nature of our support of Weather Bureau activities.

The CHAIRMAN. All right, Doctor.

Dr. DROESSLER. Mr. Chairman, we make no distinction between the scientists working for the Government and those engaged in research work and in universities or kindred institutions. If a man working in the Federal Government has a first-class research idea and this research he would like to pursue is not in accordance with the normal mission of his department but he needs some funds for it, he may submit a proposal to us and we consider it and judge it along with the research proposals that we have in the program at that time. Most of our proposals, of course, are from universities.

The CHAIRMAN. Well, what I want to do is tie in the Weather Bureau. Last fall or last summer, the Weather Bureau was before the Select Committee on Science and Astronautics and gave an extended discussion of their work, but I did not at that time tie in the National Science Foundation. I see you are tied in by virtue of grants, but they also have authority, do they not, to do work independently of those grants?

Dr. BRODE. Oh, yes, indeed; they have authority to carry on basic scientific research appropriate to the mission of the agency.

The CHAIRMAN. Now, your budget this year for this type of work will run, you say, over $3 million.

Dr. BRODE. That is about right, sir.

The CHAIRMAN. And next year you expect to ask for $2 million additional, so it will make $5 million.

Dr. BRODE. It is actually $1.4 million for weather modification this year, which we will be able to expend, and next year we are asking for a total of $2 million for weather modification.

The CHAIRMAN. You say on page 6 of your statement $2 million additional funds have been requested for 1960.

Dr. BRODE. I am sorry, sir; that is a slight misstatement. It is not $2 million additional to the current level of support, but in addition to what we are spending this year we will spend another $2 million next year.

The CHAIRMAN. That will make a total of how much next year?

Dr. BRODE. A total of $2 million next year and $1.4 million this year. In other words, it should be $600,000 additional to the level of this year will be asked for next year in this particular program.

The CHAIRMAN. Now, this is a long-term program that you refer to. What do you propose to do in the long-term program?

Dr. BRODE. We believe it should be a long-term program because the nature of the research work is such that results cannot be achieved in a short time. The development of equipment and training of personnel is a part of the program and we hope to have a continuing, somewhat enlarging program in successive years as more people come into the activity. One of the problems, as one of the previous witnesses has stated, is the lack of manpower. We hope to train and attract into this field more people but the number of universities with adequate staff to go into an increased research project is not large, but, while we would like to see this program rise rapidly, it will be limited first by manpower shortages.

The CHAIRMAN. How many schools do you have tied in now to your program?

Dr. BRODE. There are 14 universities that give graduate work in meteorology.

The CHAIRMAN. What are those?

Dr. BRODE. Sir, I can give you the list in just a second. The universities that give the doctor's degree in meteorology are the University of California at Los Angeles, MIT, New York University, Pennsylvania State University, University of Washington, and University of Florida. The schools that give the doctor's degree with an option in meteorology are Texas A. & M., Johns Hopkins, Oregon State, St. Louis University. Those are the schools which you can get graduate degrees in meteorology.

The CHAIRMAN. You have contracts with each one of those schools?

Dr. BRODE. We do not at the moment have grants with all of those schools. We have proposals from a good many of them and we have grants with, I think, well over half of them at the present time.

The CHAIRMAN. Could you give us a list of those you have contracts with?

Dr. BRODE. We could furnish that for the record; yes.

(The requested information is as follows:)

EXHIBIT A

National Science Foundation

WEATHER MODIFICATION GRANTS AND CONTRACTS—ACTIVE AS OF FEB. 16, 1959

Project No.	Institution	Investigator	Title	Amount of grant
P-2862	University of California	Neyman, J	Randomized cloud seeding	$36,700
P-3409	University of Chicago	Byers, H	Detection of ice nucleating agents.	81,000
P-3808	Northam Electronics	Bollay, E	Freezing nuclei research	30,000
P-4037	Meteor Research, Inc	MacCready, P	Santa Barbara project	9,300
P-4136	National Bureau of Standards	McMurdie	Silver iodide studies	20,000
P-4615	University of Arizona	Battan-Kassander.	Seeding of summer cumulus clouds.	22,200
P-4807	American Geophysical Union	Smith, Waldo	Conference on cloud physics, April 1959.	25,000
Pe-5280	Foundation for Instrumentation Education and Research.	Slater	Pilot cross-disciplinary clinic on the instrumentation requirements for cloud and weather modification.	5,100
P-5298	Arthur D. Little, Inc	Vonnegut	Cloud electrification studies	50,000
P-4909	Meteorology Research, Inc	MacCready	Continued cloud physics and studies at Santa Barbara.	40,000

ATMOSPHERIC GRANTS AND CONTRACTS (OTHER THAN WEATHER MODIFICATION) ACTIVE AS OF FEB. 16, 1959

P-2565	Pennsylvania State University.	Hosler, C	Aggregation of ice crystals	$11,000
P-3114	University of Washington	Fleagle, R	Physics of atmospheric motions.	12,400
P-3980	Texas A. & M. Research Foundation.	Hood	Calcium equilibrium in sea water.	10,000
P-3716	University of Michigan	Dingle	Raindrop size spectra	40,000
P-3669	University of California at Los Angeles.	Neiburger	Cloud drop growth	64,750
P-4130	University of Wisconsin	Lettau	Convective energy transfer	22,000
P-4706	MIT	Houghton, H	Atmospheric research in the United States	52,400
P-3950	do	Willett, H. C	Solar activity on atmospheric circulation.	26,000
P-4926	Oregon State College	Decker, Fred	Precipitation radar study	5,000
P-4323	University of Illinois	Semonin	Atmospheric particulates in precipitation physics.	43,000
P-4577	University of Chicago	Newton, C	Analysis of extratropical systems.	20,000
P-4687	do	Petterssen, S	Heat and water vapor exchange processes.	37,800
P-5057	University of California, Scripps.	Rakestraw	Carbon dioxide exchange, atmosphere-ocean.	34,000

The CHAIRMAN. And those that you simply have proposals for, we would like to have that list, too.

Dr. BRODE. We can furnish that for you.

(The requested information is as follows:)

EXHIBIT B

National Science Foundation weather modification proposals on hand as of Feb. 16, 1959

Project No.	Institution	Investigator	Title	Amount requested
P-4906	Valley Hail Suppression Association.	Schleusener	Scottsbluff hail and severe storm research project.	$425,000
P-5002	University of Chicago	Byers	Research in cloud physics	696,151
P-5201	do	do	Physical effects of silver iodide seeding in the Great Plains.	596,234
P-5332	Aerometric Research, Inc	Elliott	Investigation of precipitation processes and efficiency of Pacific-coast storms.	409,000
P-5415	U.S. Department of Commerce, USWB.	Kline	Synoptic observations and studies of freezing nuclei anomalies.	68,904
P-5422	University of Arizona	Kassander, Battan, McDonald.	Physics of clouds and of cloud modification.	161,741
P-5442	Atmospheric Research Group.	MacCready	Field studies in cloud physics related to nucleation, hydrometeor development, electrification, and cloud physics.	180,000
P-5607	New York University	Woodbury	A study of statistical evaluation of weather modification.	60,000
P-5708	University of California	Neyman	Randomized cloud seeding	87,540
P-5787	Colorado State University	Schleusener	Methods of coordinating research and evaluation with an operational program of hail suppression.	69,607
Ps-5818	National Academy of Sciences.	Wilks	Conference on the design and conduct of research programs in weather modification.	10,000
P-5053	University of California at Los Angeles.	Sekera	Study of earth's planetary albedo.	58,700
P-4842	Tufts	Schell	Nature of climate changes	17,000
P-5158	Pennsylvania State University.	Blackadar	Graphical integration of 2-level models.	13,300
Ps-5467	MIT	Houghton	Atmospheric research in the United States.	50,000
P-5116	Texas A. & M	Walter J. Saucier	Stratospheric patterns	74,100
P-5173	do	Y. Sasaki	A study of mesoscale disturbances in the atmosphere by numerical methods.	35,000
P-5305	Woods Hole Oceanographic Institution.	J. S. Malkus	Atmospheric connection and its role in tropical meteorology.	156,100
P-5300	Oklahoma State University	Herbert L. Jones	Investigation of the electric field intensity near a severe storm.	23,100
P-5157	Pennsylvania State University.	C. L. Hosler	Role of orographic barriers of less than 3,000 feet in the generation and propagation of showers.	98,600
P-5307	Woods Hole Oceanographic Institution.	A. H. Woodcock	Sea-salt nuclei, their origin, physical-chemical nature, and role in atmospheric processes.	83,100

The CHAIRMAN. The nature of the proposals, I do not suppose we would want to go into now, not until they are tied down there, but at any rate that constitutes the list of those capable of doing this type of work; is that not true?

Dr. BRODE. I would say there is potential capacity in many schools which do not have departments of meteorology, since these are problems of physics and engineering and there are many physicists, engineers, and chemists, who, if attracted to the program, would be able to participate in meteorology and research.

The CHAIRMAN. Let me ask one more question and then I will recognize the members of the committee. You are having great floods in West Virginia, Kentucky, Illinois, and those areas. Have you done anything at all, in reference to scientific work, which might in any way alleviate that situation? I am from Louisiana, and we are very sensitive to these heavy rains and floods, as you know.

Dr. BRODE. We have not begun any flood-limiting program. We have been working largely on making it rain rather than quit raining.

The CHAIRMAN. It is all right to make it rain, but in the right place now. Somebody out there is making it rain in the wrong place. Has there been any thought given that at all, because some of the people are really suffering today and, if we are going to have a rain control or weather control program, it would seem to me that you could give thought and attention to eliminating the rain in the wrong place.

Mr. FULTON. You are not inferring that the National Science Foundation, by monkeying with the weather, is causing floods and tornadoes.

Dr. BRODE. We are concerned with that.

Mr. FULTON. You are concerned that you are doing it?

Dr. BRODE. We want to be careful in our research program that we know what we are doing and what damage may result from our actions.

Mr. FULTON. It has caused you worry that you might be monkeying with the weather?

Dr. BRODE. Yes.

The CHAIRMAN. Let me hasten to ask you, Doctor, you have not done anything thus far that in any way would bring down precipitation in Illinois, Oklahoma, and Kentucky, and those areas, and Pennsylvania, have you?

Dr. BRODE. We are not aware that we have done that, although a small program of cloud seeding was carried out in Kentucky at one time, but that was several years ago.

The CHAIRMAN. That would not affect the situation now.

Dr. BRODE. I doubt it.

The CHAIRMAN. But had you brought this rain down in California, Arizona, and New Mexico, some of those States that perhaps could use it, it might not fall elsewhere.

Mr. MILLER. Might I say if he brought it down at the proper time of the year. In California and some of these States we get just as much rain as they get in Ohio and even Louisiana. Right now we are in the same boat as Louisiana; it comes at the wrong season of the year. It comes in bunches. We would like to spread it out. That is what we would like to see and do.

Dr. BRODE. Dr. Droessler would like to clarify this remark.

The CHAIRMAN. All right.

Dr. DROESSLER. May I just say that the National Science Foundation's program now supports only two cloud-seeding programs at the present time. One is carried out in the vicinity of Tucson, Ariz., under the direction of the University of Arizona, and the other one is NSF support for the Santa Barbara, Calif., seeding activities and the evaluation of that work. Those are the only two that we have at the present time.

The CHAIRMAN. Doctor, since you are on that subject, have you tried any experiments with nuclear tests to determine what effect that would have in the control of weather?

Dr. DROESSLER. This is a problem which has been under constant study by the Atomic Energy Commission, some of its meteorologists, and some meteorologists of the U.S. Weather Bureau, ever since the United States started testing atomic and hydrogen bombs. To date, the results of their studies do not show any correlation between weather patterns and the explosion of these high-energy bombs.

The CHAIRMAN. Dr. Brode seems to want to say something.

Mr. TEAGUE. Mr. Chairman.

The CHAIRMAN. All right, Mr. Teague.

Mr. TEAGUE. Doctor, you spoke of your budget. What about the budget of these other agencies doing work along this line? In other words, is this a coordinated program now, and do you people head it or are different Government agencies going off in different directions as far as weather is concerned? It seems up to this time, at least until the last couple of years, that each agency has gone off just about the way they wanted to, and it seems to me someone should be coordinating this program and it certainly should not be duplicated.

Dr. BRODE. We believe it is our responsibility to coordinate the program insofar as we can, and we have called together the representatives of each of the agencies which engage in weather modification activities and they have all prepared reports and submitted them to us. We are preparing this as a group report to transmit back to the agencies so that everybody will be informed in the Government agencies regarding the activities that are carried on at the present time. This is the first step in coordination, and this is just since this act came into effect last July that we have formed this Committee.

They have met and will continue to meet in an effort to keep a continued coordination program.

Mr. TEAGUE. Do you consider there to be duplication in the program now?

Dr. BRODE. No; I do not consider there is duplication in the program because the total amount of work undertaken in this experimental activity—and it is experimental activity and we need more data; we are not getting enough data at the present time—and I think there is no evidence of duplication in the program at the present time.

Mr. TEAGUE. Thank you.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Thank you. I am glad to see you here, especially Dr. Brode, who testified before. Are you telling me if we take the ups and downs out of the budget control of the weather program that you can take the disappointments out of weather for us?

Dr. BRODE. No; I would not make any such rash promises as that, but we will do our best. The scientific program, as I said, is a long-range program involving training of people, building up of machines and equipment that are very complicated, and getting records over years. This is an important part of our studies. So we need the possibility of long-range planning and programing in this research.

Mr. FULTON. I agree with the chairman, and am going to ask you to put into the record the program on hurricane, tornado, and flood control research done by your department. I will give you some

questions and you can put the answers into the record, and that will be all right. I would like to know about the Interdepartmental Committee on Weather Modification. The background and history of that.

(The requested information is as follows:)

EXHIBIT C

ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION RELATING TO HURRICANE, TORNADO, AND FLOOD RESEARCH

Considerable basic research is needed to provide a basis for the application of methods which will serve to minimize the destructive nature of severe storms such as hurricanes, tornadoes, and flash floods. All research supported by the atmospheric sciences program of the National Science Foundation (including weather modification research) helps to broaden understanding of the behavior of the atmosphere, thereby increasing knowledge of the atmospheric mechanisms of these occurrences. The national hurricane research project of the U.S. Weather Bureau, which utilizes the research capabilities of numerous universities and other organizations, is an example of a large research effort specifically directed toward the study of the structure, development, and forecasting of these particularly damaging storms. The more basic research information which can be made available with respect to such storms, however, the more rapid will be the progress toward their control.

EXHIBIT D

BACKGROUND AND MEMBERSHIP OF THE INTERDEPARTMENTAL COMMITTEE ON WEATHER MODIFICATION

The Interdepartmental Committee on Weather Modification was established by the National Science Foundation to carry out its broad responsibilities under Public Law 510, 85th Congress. In formulating a national program in weather modification, the Foundation desired to bring together other Government agencies having program interests in weather modification activities, particularly in the applied phases of the work, such as the water resources responsibilities of the Department of the Interior and the weather forecasting responsibilities of the Weather Bureau. The Committee has two primary functions: (1) To keep the various Government activities fully advised of the national efforts in the field of weather modification, and (2) to encourage coordination among the related programs of interested agencies so as to develop a national program in weather modification. The National Science Foundation serves as a focal point for all information on Government operations and research in weather modification. The members of the Interdepartmental Committee are as follows:

Department of Agriculture: Dr. H. A. Rodenhiser, Assistant Administrator, Agricultural Research Services.

Department of Commerce: Dr. F. W. Reichelderfer, Chief, Weather Bureau.

Department of Defense: Mr. Willis B. Foster, Office of Science, Office of Secretary of Defense.

Army: Dr. Hoyt L. Lemmons, Geophysical Sciences Branch, Office of Chief of Research and Development.

Navy: Mrs. Dorothy M. Gilford, Head, Statistics Branch, Office of Naval Research.

Air Force: Lt. Col. Marshall V. Jamison, Chief, Astrophysics Branch, Headquarters, USAF.

Department of Health, Education, and Welfare: Dr. John Ludwig, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Department of Interior: Dr. Luna B. Leopold, Chief Hydraulic Engineer, U.S. Geological Survey.

National Science Foundation: Dr. Earl G. Droessler, Program Director for Atmospheric Sciences, Chairman.

The CHAIRMAN. Let us get it now.

Dr. BRODE. A representative from the Department of Agriculture, Dr. H. A. Rodenheiser; Department of Commerce, F. W. Reichelderfer, the Chief of the Weather Bureau; the Department of Defense, Mr. Willis B. Foster; from the Army, Dr. Dwight L. Lemmons; from the Navy, Mrs. Dorothy Gilford; from the Air Force, Lt. Col. Marshall Jamison; from the Department of Health, Education, and Welfare, Dr. John Ludwig; from the Department of the Interior, Dr. L. Leopold; and from the National Science Foundation, and Chairman of the Committee, is Dr. Earl G. Droessler.

Mr. MILLER. You have no one on there from the Coast Guard? Are they not concerned with the weather and pretty familiar with it?

Dr. BRODE. We tried to get together those in active research on weather. The Coast Guard, to my knowledge, does not have an active research program. They are, of course, concerned with weather.

The CHAIRMAN. Doctor, did you want to say something?

Dr. GUSTAVSON. May I just introduce a sentence or two with respect to development of the program. Out in western Nebraska, in the Scottsbluff area, we have an area of heavy hail, tremendous losses. The problem here is to see what can be done to prevent the hail from falling. Now, we have a lot of people out in that part of the State and surrounding neighborhood who would love to have contracts to overseed with the promise of stopping the hail. On the other hand, there is a great university—I had the privilege of heading it for 8 years, so I would naturally call it a great university—which has the possibility of developing a group that will make a serious study and carry out research in this area. While there is no application from the University of Nebraska at the moment, while there is no definite sum set aside for it, we have had a series of conferences with the heads of the university, looking forward to getting established in that area. Such a group can do evaluation studies, some of them getting their training under Dr. Woodbury at New York University, for example, so that careful studies can be made in this area, and also bringing together a group of young, imaginative physicists, some people from chemistry, some from meteorology, et cetera, to give us a nucleus to establish this problem.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. I hope that will not be considered my time, Mr. Chairman.

The CHAIRMAN. It was very valuable information. If I were the gentleman, I would claim it.

Mr. FULTON. I think it should be a part of your statement, as a matter of fact. We had testimony before the select committee last year that there would be a $2 billion economic saving every year if we were able to have weather forecasting on various kinds of weather, rainfall, hurricanes, tornadoes, storms; so that we really have a tremendous gain out of this, and I hear there is only $1.6 million being spent by your agency each year. Do you think that is enough, and if you had more money what could you do? For example, I have had no evidence given to me so far of anything to do with the sun's radiation and the effect of the storms on the sun and weather, whereas there has been a pretty good correlation of 30-day weather disturbances after the storms. You see, in many of these fields your statement does not seem

to check. Rather than going into them, I would like to point out a few and have you put them into the record.

When you are spending one-half of your money on water, to me you are not getting enough money, and I am a Republican.

Mr. ANFUSO. What was that last statement?

Mr. FULTON. I am a conservative. Could you give us your bilateral liaison work in the record later. Give us a history of NACA and the new NASA. How you are set up bilaterally with ARPA, and as well as with other scientific bodies in the United States. Likewise I would like to know what kind of liaison you have with the scientific attachés in the Department of State which I have heard Dr. Brode testify on at one other time.

As a matter of fact, I would like to know the history of your cooperation with and participation in the International Geophysical Year and how you are possibly carrying some of the things started forward.

(The requested information is as follows:)

EXHIBIT E

BILATERAL LIAISON WORK INVOLVING THE NATIONAL SCIENCE FOUNDATION

(A) GENERAL COMMENT

The answer to this question primarily discusses liaison activities engaged in by the Foundation with respect to the Department of Defense, including the Advanced Research Projects Agency, and with the Office of Science Adviser of the Department of State and the science attachés of the Department stationed at embassies abroad. It is impossible to apply literally the part of the question which is directed to the kind of liaison performed "with other scientific bodies in the United States" because in the conduct of its programs the Foundation is intimately involved with a large number of scientific groups and organizations throughout the United States, which certainly number several score and may well run into the hundreds.

Furthermore, it would be inaccurate to refer to these relationships as "liaison." The relationship with many of them is that of acquiring counsel and advice. In hardly any programs undertaken or financed by the Foundation do we proceed without first securing the reactions and suggestions of the scientific societies and other organizations. Also, a number of the Foundation programs are carried on through grants and contracts with scientific societies and other organizations. For example, the "traveling science library" program of the Foundation, designed to bring to high schools with inadequate library facilities an occasional opportunity to utilize texts and other books in various fields of science, is carried on under a grant from the Foundation to the American Association for the Advancement of Science. The Foundation frequently makes grants to scientific societies for the support of travel of U.S. scientists to attend international scientific meetings held overseas. A more organized presentation of the relationships of the Foundation to the many scientific bodies in the United States can be obtained from the Foundation's annual report, a copy of which is enclosed.

(B) RELATIONSHIPS WITH THE DEPARTMENT OF DEFENSE, INCLUDING THE ADVANCED RESEARCH PROJECTS AGENCY

Here again, because of the broad interests of both the Department of Defense and the National Science Foundation in the support of scientific research in many fields, it is practicable in this letter to summarize only the principal areas of relationship and liaison.

The Director of the National Science Foundation serves as a member of the Defense Science Board, which is made up of 25 members partially from outside the Government and partially from science administrators within the Government. The Board renders general scientific advice to the Secretary of Defense on various aspects of the research-and-development activities carried on by the Department and the impact of research upon warfare concepts and weapons.

The Director of the Foundation also serves as a member of a general science panel which advises the Director of Defense Research and Engineering on programs and policies of the Department of Defense which relate to basic scientific research.

The National Science Foundation is represented on an internal coordinating committee on basic sciences, which is chaired by the Director for the Office of Sciences in the Department of Defense and is made up of representatives of those parts of the three military services primarily concerned with the support of basic research. At the present time the Foundation's representative, who is actually in the status of observer, is the Associate Director for Research.

The heads of divisions and offices of the Foundation concerned with the support of basic research are in contact on a continuing basis with their counterparts in the Department of Defense. Generally speaking, these liaison arrangements, both formal and informal, are concentrated toward those parts of the Department of Defense which are especially concerned with the support, through contracts and grants, of basic research at colleges and universities. These groups include the Office of Naval Research in the Navy, the Office of Scientific Research in the Air Force, and the Office of Ordnance Research in the Army. In these formal and informal contacts, information is exchanged between the two agencies on the kinds of basic research programs and projects being supported or being contemplated for support.

In the field of scientific information the Foundation maintains a number of relationships with the Department of Defense, including the Office of the Director of Defense Research and Engineering and the Armed Services Technical Information Agency. In carrying out its responsibilities pursuant to title IX of the National Defense Education Act, and to directives received from the President with respect to the undertaking of programs to improve the dissemination of scientific information, the Foundation recently established an Advisory Committee on Scientific Information chaired by the head of the Office of Science Information Service of the National Science Foundation and made up of representatives of the various agencies concerned with the publication and dissemination of scientific information. The Committee was established for the purpose of advising the Foundation as to governmental activities in this field and programs for their improvement which might be undertaken. Representatives of the Department of Defense including its constituent military services sit on this Committee. In a related connection, the National Science Foundation in the fairly recent past chaired a committee set up to explore ways of improving the operational relationships between the Armed Services Technical Information Agency of the Department of Defense and the Office of Technical Services of the Department of Commerce.

Liaison and other working arrangements between the Foundation and the ARPA have been concerned primarily with the IGY program and, more recently, with the conduct and support of basic research in outer space. During the period following the establishment of ARPA and before the establishment of NASA, the National Science Foundation exchanged information with ARPA on various aspects of planning for IGY satellites and, in behalf of the U.S. National Committee for the IGY, presented information and advice to ARPA as to instrument "packages" to be carried by Department of Defense satellite vehicles, schedules of shots, etc.

Representatives of National Science Foundation interchange information on a continuing basis with representatives of ARPA and of NASA regarding proposals received for the support of basic research in outer space. In this connection a Space Science Board, established by the National Academy of Sciences upon the recommendation of the National Science Foundation, gives advice to NASA, ARPA, and the Foundation regarding programs of scientific experimentation in outer space. Representatives of the three agencies consult on a continuing basis with the Space Science Board and with scientific advisory panels established by the Board.

(c) RELATIONSHIPS WITH THE DEPARTMENT OF STATE

The National Science Foundation maintains day-to-day relationships with the Office of the Science Adviser in particular and on occasion with other divisions of the Department. The National Science Foundation played an advisory role in encouraging reinstatement of the science attaché program within the Department of State, and its day-to-day working relations with the Office of Science

Adviser have included such arrangements as the briefing of newly appointed science attachés on National Science Foundation activities before their departure for oversea posts and the nomination of candidates by National Science Foundation for unfilled posts of science attachés. In addition, informal discussions have been held among representatives of the National Science Foundation and State regarding coordinated scientific activities, particularly in the field of scientific information.

Related to its liaison arrangements with the science adviser and science attachés, the National Science Foundation participates in advising the U.S. member of the Science Committee of NATO (Dr. I. Rabi). In a further related connection, the Foundation renders technical and scientific advice to the International Cooperation Administration in connection with scientific activities undertaken as a part of ICA programs and projects overseas, under a memorandum of agreement entered into between ICA and the Foundation.

EXHIBIT F

A BRIEF HISTORY OF NASA

The National Aeronautics and Space Administration, an independent Government agency concerned with aeronautical and space research, was born in mid-1958. The nucleus around which it was built—the National Advisory Committee for Aeronautics—was founded in 1915.

The National Aeronautics and Space Administration has been growing rapidly since President Eisenhower recommended its creation in a special message to the Congress on April 2, and signed it into law on July 29, 1958. It became effectively operative on October 1, 1958, when it absorbed the personnel and facilities of NACA, including nearly 8,000 scientists, engineers, and administrative personnel in its Washington, D.C., headquarters and 5 laboratories in 3 States.[1]

NASA's mission, however, is far broader than that of NACA which was concerned primarily with basic research in aircraft and rockets. The new agency is charged with development of aircraft, rockets, satellites, "and other space vehicles—manned and unmanned—together with related equipment, devices, components and parts."

In his special message, President Eisenhower said that NASA should direct the Nation's space program, apart from military projects, and that this program "should contribute to—

"(1) the expansion of human knowledge of outer space and the use of space technology for scientific inquiry;

"(2) the improvement of the usefulness and efficiency of aircraft;

"(3) the development of vehicles capable of carrying instruments, equipment, and living organisms into space;

"(4) the preservation of the role of the United States as a leader in aeronautical and space science and technology;

"(5) the making available of discoveries of military value to agencies directly concerned with national security;

"(6) the promotion of cooperation with other nations in space and technology; and

"(7) assuring the most effective utilization of the scientific and engineering resources of the United States and the avoidance of duplication of facilities and equipment."

The President said this country's space activities should be sponsored by a civilian agency "because space exploration holds promise of adding importantly to our knowledge of the earth, the solar system, and the universe, and because it is of great importance to have the fullest cooperation of the scientific community at home and abroad in moving forward in the fields of space science and technology. Moreover, a civilian setting for the administration of space function will emphasize the concern of our Nation that outer space be devoted to peaceful and scientific purposes. * * *"

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[1] Langley Research Center, Langley Field, Va.; the Pilotless Aircraft Research Station, Wallops Island, Va.; Ames Research Center, Moffett Field, Calif.; the High-Speed Flight Station, Edwards, Calif.; Lewis Research Center, Cleveland, Ohio.

The President named T. Keith Glennan, president on leave of Case Institute of Technology in Cleveland, as NASA's first Administrator. Dr. Hugh L. Dryden, who was NACA's Director for 9 years, is Deputy Administrator.

A nine-member National Aeronautics and Space Council, headed by the President of the United States, governs NASA. Its members include the Secretaries of State and Defense, Chairman of the Atomic Energy Commission, the NASA Administrator, the Director of the National Science Foundation, the President of the National Academy of Sciences (a private organization), and two other non-Government members from private industry or educational scientific fields. This year's (1959) members: Gen. James H. Doolittle (retired), chairman of the board, Space Technology Laboratories, Los Angeles, Calif., and William A.M. Burden, general partner, William A. M. Burden & Co., investment bankers, New York City, N.Y.

In early October, Mr. Glennan announced that NASA's organizational structure would include space-flight development and aeronautical and space research.

He named Dr. Abe Silverstein Director of Space Fight Development and John W. Crowley, Jr., Director of Aeronautical and Space Research.

Albert F. Siepert was named Director of Business Administration.

Prior to enactment of the National Aeronautics and Space Act of 1958, President Eisenhower called upon the Department of Defense and NACA to carry out a joint review of aeronautical and space projects which should, appropriately, be placed under direction of the new civilian agency. As a result of this continuing review, the President issued an Executive order on October 1, transferring the following projects to NASA:

(1) Project Vanguard, with more than 150 scientists under the direction of Dr. John P. Hagen, of the Naval Research Laboratory in Washington, D.C.

(2) Four lunar and space probes which were under the aegis of the Defense Department's Advanced Research Projects Agency.

(3) Three ARPA satellite projects: 12-foot- and 100-foot-diameter inflatable spheres and a cosmic-ray experiment.

(4) A number of Air Force engine development research programs, including basic research in nuclear and fluorine rocket engines and study and development of a 1-million-pound-thrust single-chamber rocket engine.

The United States Air Force Ballistic Missile Division was executive for the three lunar probes (the first one was carried out under ARPA direction); the U.S. Army Ballistic Missile Agency was executive agent for two. They were carried out in the summer and fall of 1958 under NASA management as part of this country's contribution to the International Geophysical Year program. They produced valuable data on micrometeorite impacts, the density of the two so-called Van Allen radiation belts surrounding the earth, the make-up of the earth's magnetic field, to name a few of the experiments.

William J. O'Sullivan, Jr., head of the Space Vehicle Group at NASA's Langley Research Center, designed the inflatable spheres, as well as a 30-inch-diameter inflatable subsatellite. The 12-footer, designed to provide air density data and serve as a radar target, is, like the 30-incher, made of microthin aluminum foil and Mylar plastic film. The 100-foot sphere is made of lighter composition.

In November, NASA provided missile and airplane manufacturers with specifications for development of a space capsule suitable for use in manned-satellite flight—a project originally under ARPA jurisdiction.

As it moves forward with these and other projects, NASA will be building upon an extensive NACA heritage. NACA was established in 1915 because the United States was falling behind Europe in aircraft research and development. Over the years it concerned itself with directed research of a fundamental nature, research having application to broad categories of aircraft and rockets. These concepts were then tested in NACA's wind tunnels and test ranges such as Wallops Island before finding their way into military and commercial aircraft.

One of NACA's earliest breakthroughs took place in 1929. A NACA engineer discovered that he could increase an airplane's speed up to 15 percent by placing a cowling over the exposed pistons of an aircooled engine.

During its last decade, NACA underwent a gradual change in emphasis from airplanes to research on missiles and space vehicles. By mid-1958, about half of the organization's research effort was devoted to the latter. An interesting

example of this evolution is the X–15, the rocket-powered airplane which was made available for public inspection on October 15, 1958, at North American Aviation's Inglewood, Calif., plant. Like the Bell X–1, Bell X–2, and the other research aircraft which preceded it, the X–15 is a flying laboratory packed with more than 1,000 pounds of highly sensitive instruments for gathering scientific data. It is a joint U.S. Air Force-NASA-Navy project designed to explore the problems of manned space flight.

Despite this transition from airplanes to spacecraft, NASA will devote a major part of its research to the former for many years to come. The Convair B–58, this country's first supersonic bomber, for example, makes use of NASA's "area rule" principle (the so-called coke-bottle shape) and the projected B–70 bomber contains several more recent classified NASA developments.

With new knowledge of aerodynamics, powerplants, and structures, areonautical science can be extended to provide a heavy, efficient airplane capable of flying large loads at 2,000 miles per hour over intercontinental distances.

NASA is equally interested in low-speed aircraft and the entire spectrum of aircraft operating problems such as safety, runway construction, engine noise, etc.

EXHIBIT G

HISTORY OF COOPERATIVE EFFORTS DURING THE INTERNATIONAL GEOPHYSICAL YEAR AND DISCUSSION OF ACTIVITIES CARRYING OUT PROGRAMS BEGUN DURING THE INTERNATIONAL GEOPHYSICAL YEAR

I. HISTORICAL BACKGROUND AND INTERNATIONAL ORGANIZATION OF THE IGY

The period July 1, 1957, through December 31, 1958, was designated as the International Geophysical Year. It was a period of worldwide observations and studies of the sun, and of the earth and its physical environment, including its atmosphere and the space through which it travels. Sixty-six nations took an active part in the program (listed below).

The IGY was actually the third such scientific undertaking. During 1882–83, the first polar year, 10 nations, including the United States, conducted simultaneous cooperative scientific observations in the Arctic. Fifty years later the second polar year, 1932–33, was undertaken, in which 30 nations cooperated in observations primarily in the Arctic. Both of these periods contributed greatly to the store of basic knowledge in the geophysical sciences.

In April 1950 at an informal meeting of geophysicists in this country the suggestion was offered that, because of the tremendous advances in instrumentation that had taken place in the 1940's, consideration be given to holding a third polar year 25 years after the second, which would place it in 1957–58, a period of maximum sunspot activity. The suggestion was received with enthusiasm, and in subsequent discussions scientists throughout the world recognized the benefits of extending the planned program to encompass the entire earth and renamed it the International Geophysical Year to reflect the increased scope in coverage.

During the next 18 months the initial proposal was considered and supported by a number of international scientific groups, most of them members of the International Council of Scientific Unions (ICSU). The Mixed Commission on the Ionosphere endorsed it as did, also, in rapid succession, the International Scientific Radio Union, the International Astronomical Union, the International Union of Geodesy and Geophysics, and finally the International Council of Scientific Unions itself.

In 1951 the Executive Board of ICSU appointed the Comité Spécial de l' Année Géophysique Internationale (CSAGI), composed of representatives of the various scientific unions involved and the World Meteorological Organization and the International Consultative Committee for Radio Communications. A Bureau of CSAGI was appointed consisting of Prof. Sydney Chapman (Great Britain), president; Dr. Lloyd V. Berkner (United States), vice president; and Prof. M. Nicolet (Belgium), general secretary. Later (in June 1957) Prof. V. V. Beloussov (U.S.S.R.) and Prof. J. Coulomb (France) were added as members of the Bureau.

In late 1951 and early 1952 CSAGI invited member nations of ICSU to establish special national committees to take part in the planning and guidance of

the IGY. As the concept of the IGY expanded, invitations to all countries of the world were issued to join in the enterprise.

A coordinated worldwide scientific program for the IGY was synthesized from various proposals submitted by individual nations and modified through periodic meetings of CSAGI (Brussels, 1953; Rome, 1954; Brussels, 1955; Barcelona, 1956; Moscow, 1958).

II. U.S. PARTICIPATION IN THE INTERNATIONAL GEOPHYSICAL YEAR

U.S. National Committee for the IGY

The National Academy of Sciences-National Research Council, a nongovernmental organization, as the adhering body on behalf of American scientists to the International Council of Scientific Unions and most of its Unions, was the group in the United States that received the CSAGI invitation for this country to participate in the IGY. In response to this invitation, the Academy-Council established in February 1953, the U.S. National Committee for the International Geophysical Year 1957–58, under the chairmanship of Dr. Joseph Kaplan, professor of physics at the University of California at Los Angeles. Dr. Alan H. Shapley, of the National Bureau of Standards, was named vice chairman, and Mr. Hugh O'Ishaw, formerly of the National Bureau of Standards, the executive director. The committee membership included appropriate representation from the various scientific disciplines involved; subcommittees were named to cover the regional programs planned (Arctic, Antarctic, Equatorial Regions); and 13 technical panels were established to direct the program in the scientific disciplines of meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, longitude and latitude, glaciology, oceanography, seismology, gravity, and in the programs of rocketry and communications.

Role of the National Science Foundation in the IGY

The Academy-Council recognized the importance of Government cooperation and support to the success of the U.S. portion of the IGY program. On November 25, 1953, the Academy-Council transmitted to the National Science Foundation the recommendation of the U.S. National Committee for the IGY that the Foundation be asked to take responsibility for obtaining and administering Government funds required to carry out the program and to coordinate the interests of Government agencies involved.

After consideration of the recommendation and a study of the proposed program and budget, the National Science Board at its meeting of January 29, 1954, endorsed the program and the Foundation's participation in it. With the endorsement of the administration, the Foundation proceeded with the implementation of U.S. plans, including the coordination of Government interests in the program.

After submission of the proposed budget and program for the IGY to the Bureau of the Budget, and the submission of letters of support for the program to the Bureau of the Budget from the Departments of State, Defense, and Commerce, the Atomic Energy Commission, and the Office of Defense Mobilization, the President approved the program and included the requested amount for the National Science Foundation in support of the International Geophysical Year in a supplemental appropriation request for fiscal year 1955. Action by the Congress was approval of an initial appropriation of $2 million for the IGY program (Supplemental Appropriations Act of 1955, 83d Cong., 2d sess.). Subsequent appropriations to the National Science Foundation for the program have been $10 million (Independent Offices Appropriations Act of 1956, 84th Cong., 1st sess.); $27 million (Second Supplemental Appropriations Act of 1956, 84th Cong., 2d sess.); $2 million (Second Supplemental Appropriations Act of 1958, 85th Cong., 2d sess.); $2,500,000 (Supplemental Appropriations Act of 1959, 85th Cong., 2d sess.). The total amount therefore appropriated to date for the IGY program is $43,500,000.

Fundings of the various projects in the U.S. IGY program have been administered through the regular grants procedure of the National Science Foundation, upon recommendations received from the U.S. National Committee for the IGY. As of January 31, 1959, $42,350,000 has been granted or transferred by the National Science Foundation to institutions or agencies engaged in the IGY program. The remaining $1,150,000 will be funded primarily for World Data Center activities interdisciplinary research activities utilizing IGY data.

Four special reports on the IGY program have been made upon request to congressional committees. On March 28, 1956, there was transmitted to the chairman of the Subcommittee on Independent Offices Appropriations and Government Matters, U.S. Senate, a special report on the International Geophysical Year prepared for the Senate Committee on Appropriations, which was published in May 1956 as Senate Document No. 124, 84th Congress, 2d session. On May 1, 1957, members of the U.S. National Committee for the IGY, representatives of the Committee's secretariat, and the National Science Foundation appeared before the Subcommittee on Independent Offices, Committee on Appropriations, House of Representatives, at the request of the chairman, to give a progress report on the IGY program. This report was published as "Report on International Geopyhsical Year" (hearing before the subcommittee of the Committee on Appropriations, House of Representatives, 85th Cong., 1st sess.). A further progress report on the IGY was given by members of the U.S. National Committee for the IGY and its technical panels to the Subcommittee on Independent Offices, Committee on Appropriations, House of Representatives, June 2–3, 1958, and published as "Review of the First 11 Months of the International Geophysical Year" (hearings before the subcommittee of the Committee on Appropriations, House of Representatives, 85th Cong., 2d sess.). A third oral report to the same subcommittee of the House of Representatives of the U.S. National Committee for the IGY and the National Science Foundation was given on February 18, 1959. This report covered preliminary results of the entire 18-month period of the IGY and will be published as a congressional document.

Other Government agencies involved in the IGY

The National Science Foundation, in order to assure coordination, has worked closely with other Federal agencies having an active interest and role in the IGY. These include the Department of Defense, Weather Bureau, National Bureau of Standards, Coast and Geodetic Survey, and Geological Survey.

The Department of Defense was involved in the IGY program primarily in the Antarctic and earth satellite projects. In the case of the former, the Defense contribution included all logistics support, construction of facilities, station-keeping personnel, and transportation services. For the satellite program, agreements were reached with the Department of Defense to develop and supply suitable launching vehicles, procure range-operation costs, place satellites in orbit, and establish confirmation of the orbit, the latter involving certain parts *of the ground electronics setup. The National Science Foundation agreed, as* far as the earth-satellite project was concerned, to furnish funds for the scientific instrumentation, parts of the electronic ground operations, the optical-tracking ground station network, and the substantial part of the radio-tracking and telemetry network.

III. RELATIONS WITH OTHER COUNTRIES PARTICIPATING IN THE IGY

As far as relationships with other countries are concerned, the IGY was a nongovernmental type of undertaking. Agreements and understandings were between the scientists and the scientific organizations of the countries and were not characterized by formal agreements, treaties, or other types of documentation that are used in the case of intergovernmental relationships.

To qualify as a participant in the IGY it was necessary only that the scientific organization representing a country agree to carry out certain appropriate scientific and geophysical programs within its own continental limits, possessions, or territories in which it had traditionally had an interest, that it appoint a special committee of appropriate scientists to organize and execute its scientific program, and that it agree to make the data therefrom available through planned IGY world data centers.

In order to assure ready availability of all data, the CSAGI recommended the establishment of three world data centers. These have been established and are in operation under CSAGI agreements. They are World Data Center A, maintained by the United States; World Data Center B, established by the

U.S.S.R., and World Data Center C, composed of eight nations of Western Europe (Sweden, Spain, France, Italy, Switzerland, United Kingdom, the German Federal Republic), and centers in Japan and Australia. The location and organization of these three centers will serve the geographical convenience of the scientists of all nations.

All original IGY data is sent to one or more of the three world data centers, where it is cataloged and stored. The receiving center in turn immediately makes copies of the data for the other two centers if these have not been supplied, and provides these copies free of charge. Thus three complete sets of IGY data are coming into existence. The world data centers issue periodic catalog lists of the data in their archives at the end of each 6 months of the period of the IGY, and any institution or individual may obtain copies of the data from a center at a nominal sum to cover reproduction costs.

The U.S. World Data Center is directed by the National Academy of Sciences' Coordination Office, Washington, D.C., and is organized into 11 subcenters, each responsible for the handling of data in a particular discipline or disciplines.

IV. PRELIMINARY RESULTS OF THE IGY

Attached are copies of the two latest published congressional reports and a two-part article summarizing the preliminary results by the Executive Director, USNC–IGY.

V. CONTINUATION OF PROGRAMS BEGUN AS PART OF THE IGY

Inevitably, the IGY program has stimulated an increase in the numbers of project proposals for basic research in the earth sciences and related fields. These proposals come into the Foundation and are considered as a part of the overall support of basic research.

In addition, certain programs have been identified more explicitly, as, for example, Antarctic activities and space research.

In the case of the Antarctic, the National Science Foundation has, by mutual agreement within the executive branch, accepted responsibility for coordinating and seeking funds for a scientific program in the Antarctic. Logistic support of this operation is provided by the Department of the Navy. This will be a continuing program.

In the case of space research, the Foundation will participate in certain basic aspects of this program. The relationships between the Foundation and other Government agencies, particularly NASA, have been indicated in answers to question No. 1.

There is now under discussion an extensive program in oceanographic research, which will undoubtedly receive support from various agencies of the Government, including the National Science Foundation.

Special aspects of meteorological research have also been stimulated as a result of the IGY and other factors, and here again the Foundation will have a share in the support of the basic research aspects of such programs.

The final results of the IGY program will consist of great quantities of processed data, which will provide material for research projects in many fields of science. The functions of the world data centers (described under question 2) will, of course, be continuing ones, since these data will be useful for many years and must be readily available for the scientific community of the world.

Countries participating in the International Geophysical Year

Argentina	Ireland
Australia	Israel
Austria	Italy
Belgium	Japan
Bolivia	Korea, Democratic Republic of
Brazil	Malaya
Bulgaria	Mexico
Burma	Mongolian Peoples Republic
Canada	Morocco
Ceylon	Netherlands
Chile	New Zealand
China : Taipei	Norway
Colombia	Pakistan
Cuba	Panama
Czechoslovakia	Peru
Denmark	Philippines
Dominican Republic	Poland
East Africa	Portugal
Ecuador	Rhodesia, Southern
Egypt	Rumania
Ethiopia	Spain
Finland	Sweden
France	Switzerland
German Democratic Republic	Tunisia
German Federal Republic	Union of South Africa
Ghana	Union of Soviet Socialist Republics
Greece	United Kingdom
Guatemala	United States
Hungary	Uruguay
Iceland	Venezuela
India	Vietnam Democratic Republic
Indonesia	Vietnam (Republic)
Iran	Yugoslavia

April 15, 1958 (66 countries).

Mr. MILLER. To keep the record straight, would the gentleman yield at this point?

Mr. FULTON. I would be glad to.

Mr. MILLER. You said you heard Dr. Brode testify with respect to the scientific attachés. I was wondering whether it was this Dr. Brode or his twin brother—you cannot tell apart—who is Head of Science in the State Department.

Mr. FULTON. I am glad there are two of them. I am glad it is not one man with two heads.

Mr. MILLER. Well, I want to tell you each one of them is equal to a man with two heads.

Mr. FULTON. Well, they dress alike and look alike.

The CHAIRMAN. We have a long way to go. This levity is interesting.

Mr. FULTON. Likewise I would like to know what kind of setup you have as to cooperation with other countries, either bilaterally or multilaterally and also with international agencies such as under the United Nations. Likewise I would like to have you put into the record what has been happening on the Arctic and Antarctic programs and our installations there, and likewise I would like to have you put in the record what you are doing on the observation, reconnaissance, and the so-called weather satellites we are going to put up in the future. Just one minute and I am through.

(The requested information is as follows:)

EXHIBIT H

ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION INVOLVING COOPERATION WITH OTHER COUNTRIES OR WITH INTERNATIONAL AGENCIES

Section 13 of the National Science Foundation Act of 1950 states the following:

"INTERNATIONAL COOPERATION AND COORDINATION WITH FOREIGN POLICY

"SEC. 13 (a) The Foundation is hereby authorized to cooperate in any international scientific research activities consistent with the purposes of this Act and to expend for such international scientific research activities such sums within the limit of appropriated funds as the Foundation may deem desirable. The Director, with the approval of the Board, may defray the expenses of representatives of Government agencies and other organizations and of individual scientists to accredited international scientific congresses and meetings whenever he deems it necessary in the promotion of the objectives of this Act.

"(b) (1) The authority to enter into contracts or other arrangements with organizations or individuals in foreign countries and with agencies of foreign countries, as provided in section 11(*c*), and the authority to cooperate in international scientific research activities as provided in subsection (a) of this section, shall be exercised only with the approval of the Secretary of State, to the end that such authority shall be exercised in such manner as is consistent with the foreign policy objectives of the United States.

"(2) If, in the exercise of the authority referred to in paragraph (1) of this subsection, negotiation with foreign countries or agencies thereof becomes necessary, such negotiation shall be carried on by the Secretary of State in consultation with the Director."

The principal activities carried on by the Foundation which involve relations with other countries, institutions, and individuals within those countries and with international agencies have been: (*a*) Support of study abroad of U.S. citizens awarded NSF fellowships; (*b*) occasional grants to foreign educational and research institutions for the conduct of basic research; (*c*) support, through various means, of the interchange and dissemination of foreign science information; (*d*) serving as a coordinating agency within the Government for U.S. participation in the IGY (see exhibit G); and (*e*) participation in the International Hall of Science at the Brussels World's Fair. These activities are described in the following paragraphs:

"Under congressional authorization the National Science Foundation awards fellowships in the mathematical, physical, medical, biological, and engineering sciences, including anthropology, psychology, geography, certain interdisciplinary fields, and fields of convergency between the natural and social sciences. The Foundation makes the awards solely on the basis of ability for study at accredited nonprofit institutions of higher education in the United States or any similar institutions abroad of the recipient's choice. A number of the recipients choose foreign institutions. Total obligations for the fellowships awarded U.S. citizens for study in other countries amounted to about $628,000 for fiscal 1957.

"Shortly after its establishment in 1950, the National Science Foundation began making grants for basic research in the sciences. Some of these grants go to foreign educational and research institutions.[1] During fiscal year 1957, the Foundation made such grants to institutions in Sweden, Bermuda, Italy, Japan, and Thailand. Obligations for these grants for fiscal 1957 totaled $91,000.

"To promote the international interchange of scientific knowledge among scientists, the National Science Foundation is carrying out a program for the translation into English of scientific works published in other languages, principally Russian.

"The Foundation made its first grant for this purpose in May 1952. From July 1953 through December 1956 the Foundation supported a Russian translations depository at the Library of Congress.

"In 1958 the Foundation supported the translation of 28 Russian journals and 12 Russian scientific books, besides 2 abstract series and 1,500 pages of

[1] All grants to foreign organizations for support of basic scientific research are approved by the Department of State.

Russian mathematics articles. The Foundation also partly supported the depository of the Special Libraries Association Scientific Translations Center at the John Crerar Library in Chicago. The center maintains liaison with translation depositories of the other English-speaking nations, so that, through the aid of the Foundation, scientists in the United States have access to the entire body of unclassified scientific translations into English. Translations listed in a monthly bibliography issued by the center are available to scientists and students at a nominal cost.

"The countries most affected are those in which English is the principal language of science. However, in the case of Russian translations, other countries such as France, Belgium, and Holland, whose scientists can read English more readily than Russian, are also affected.

"Finally, with the use of funds transferred from the Department of State, the National Science Foundation organized and set up the U.S. scientific exhibits at the Brussels World's Fair of 1958. The Foundation recruited a staff for this purpose in the spring of 1957 and with the advice of leading scientists began planning and organizing the 51 exhibits at that time. A number of educational and industrial laboratories in the United States contributed money, staff time, instruments, and in several instances complete exhibits."

EXHIBIT I

ARCTIC AND ANTARCTIC PROGRAMS OF THE NATIONAL SCIENCE FOUNDATION

I. ANTARCTIC RESEARCH PROGRAM

There has been appointed under the International Council of Scientific Unions (ICSU) a Special Committee on Antarctic Research (SCAR). An important function of this Committee is to plan on an international basis a continuing scientific program in the Antarctic. The National Academy of Sciences-National Research Council named the U.S. scientific member to SCAR and the first meeting of the Committee was held at The Hague in February 1958. Recommendations were made concerning additional scientific work to be undertaken in the Antarctic as a continuation of the work being conducted during the IGY. A second meeting of SCAR was held in Moscow in August 1958 and a third meeting is planned for Canberra, Australia, in March of 1959. Through SCAR, the coordination of scientific programs of some 12 nations in the Antarctic and the exchange of unclassified information will be carried out in the same manner as has been done during the IGY.

In January 1958, the Director of the National Science Foundation, appearing before the House Committee on Interstate and Foreign Commerce, stated that the United States planned to continue scientific operations in the Antarctic beyond the IGY. The release of this statement was coordinated with similar public statements issued by the White House and the Department of the Navy.

The National Science Foundation was subsequently given responsibility for coordination of the scientific programs in the post-IGY Antarctic research plan, and assumed responsibility for the submission of a budget request for fiscal year 1958. The Congress acted upon this request by approving $2 million for the program, appropriating $1 million in May 1958, the remaining $1 million to be absorbed by the Foundation within its regular 1959 appropriation. The $2 million thus derived was for support of the scientific costs of the wintering-over party in the first post-IGY Antarctic year (commonly designated as the calendar 1959 party or team No. 1).

To act in an advisory capacity in the U.S. participation in the post-IGY Antarctic program, the National Academy of Sciences upon recommendation by the Director, National Science Foundation, in February 1958 established an Advisory Committee on Polar Research. The Committee has made recommendations to the National Science Foundation regarding a continued scientific program in the Antarctic.

The National Science Foundation presently maintains a small staff to direct the planning of the Antarctic research program. In addition, the Foundation has established the Interdepartmental Committee on Antarctic Research, composed of representatives of the Government agencies involved in the program (State, Defense, Commerce, Interior), to work on the scientific program and its apportionment so as to enable the Foundation to submit an overall plan that matches the logistics capabilities.

At present the National Science Foundation is supporting a program totaling $2 million for team No. 1. As of December 31, 1958, grants in the amount of $1,669,093 had been made in the general areas of aurora and airglow, biological, and medical sciences, geodesy and cartography, geology, geomagnetism, glaciology, gravity, ionospheric physics, meteorology, oceanography, seismology, and related field support. Of particular interest in this program is the initiation of a program in the biological and medical sciences and the beginnings of a program in geology. Of the remaining $330,907, $250,000 is earmarked for the completion of the work at home and $80,000 is retained for additional projects in the area.

A program for calendar year 1960 (team No. 2) has been proposed and forwarded to the Foundation from the Committee on Polar Research covering research in the same fields, but also including some work in cosmic rays and in rocketry. The magnitude of the support that can be made for this area will depend upon the support that is available from the task force, which at the present time is expected to be about the same for Deep Freeze V as for the present Deep Freeze IV. The Navy is now supporting logistics for a science program of $2 million from the regular budget and about $700,000 from IGY funds, giving a total program of about $2,700,000 for team No. 1. It is hoped that for the coming year an expanded budget for the science program can be supported by the task force. If this is too great, it may be necessary to reduce some parts of the program to keep it within the available space and transportation facilities that the task force can supply. In any case, the magnitude of the finally approved appropriations and allotments for science and logistics will determine the size of the final program.

For the post-IGY Antarctic program the network of seven Antarctic stations—the number maintained by the United States during the IGY—was reduced to a four-station network: the Pole Station, the Byrd Station, the McMurdo Naval Air Facility, and the Hallett Station. In addition to operating these four stations, the United States is supplying scientific personnel and equipment under cooperative arrangements with other countries at the following stations: The Scott Base (operated by New Zealand during the IGY and continued in the post-IGY period), the Wilkes Station (formerly maintained by the United States, now by Australia), and the Ellsworth Station (during the IGY operated by the United States, now maintained by Argentina). The U.S. IGY Litle America Station was shut down at the close of the IGY.

There follows a summary of the work being done at Antarctic stations by the United States:

Pole Station (Unitde States).—The full program of research started during the IGY is continuing at the Pole Station. This includes measurements of the auroras, the ionosphere, geomagnetic measurements, seismic operations, and whistler recordings, in addition to the basic three hourly surface meteorological and twice-daily upper air observations. The meteorological program has been expanded by transfer of equipment from the closed Little America Station to permit the measurements of radiation, ozone in the atmosphere, and the measurement of carbon dioxide content over 24-hour periods.

The scientific personnel at the station numbers eight persons.

Byrd Station (United States).—The program at this station is continuing the same work as before. The projects include observations of geomagnetism, aurora, seismology, isonospheric soundings, radionoise and study of whistlers. In addition to this, an extensive glaciology program is underway there also. Some traverses for gravity and magnetic studies have been operated out of Byrd Station this last year and the usual seismic measurements to determine ice thickness have continued over the area of the sector of Antarctica between Byrd Station and the South Pole. The meteorological program is continuing in much the same manner, with both surface and upper air observations as well as measurements of radiation.

Thirteen scientists are engaged in the program at this station.

McMurdo Air Facility (United States).—Heretofore the Naval Air Facility at McMurdo Sound limited its operations to the logistics support of the U.S. operations in this sector of the Antarctic. Following the closing of Little America Station, some of the equipment available at Little America was transferred to the New Zealand Scott Base to expand the cooperative program with the New Zealanders on auroral, glaciological, and gravity measurements, oceanography, and seismic soundings in this area, and some of the traverse equipment has been transferred to the garages at McMurdo for repair and preparation for traverses in the next Antarctic summer. It will be necessary to support such traverses from McMurdo next year, inasmuch as Little America will not be available for

this purpose. A biological laboratory has been provided for such work in this area. During this past Antarctic summer a survey of respiratory infections and investigations of fungus diseases in penguins was conducted. The food economy of fish in this area and the identity, distribution, abundance, and ecology of inshore marine vertebrates and invertebrates was carried out. Studies on marine fauna and land invertebrates will be made during the coming Antarctic winter. The usual standard surface and upper air meteorological observations, carried out by Navy personnel, are continuing at McMurdo.

Scientific personnel at the station includes three civilian scientists and five Navy meteorological personnel.

Hallett Station (United States-New Zealand).—The joint New Zealand-United States operation of the Hallett Station is continuing as during the IGY, with the United States furnishing the station scienitfic leader this year. Observations are continuing in aurorae, geogmagnetism, ionospheric physics, seismology. In meteorology, surface, upper-air, and radiation observations are being carried out by the station scientific leader and three Navy aerologists who are wintering over. Some biological investigations, including microbiological studies of respiratory infections on penguins, are underway. Except for four U.S. scientists, the remaining scientific staff are supplied by New Zealand.

Scott Base (New Zealand).—Through arrangements with New Zealand, the United States is participating in the scientific work at this base. The portion supplied by the United States consists in an enlarged auroral program and the work in seismic soundings there. Some work in glaciology, gravity, and oceanography is being carried out also. In the beginning of the summer of 1959–60. a U.S. traverse party, together with the New Zealanders, will carry on some seismic, gravity, magnetic, and glaciological investigations in the Victoria Land Plateau.

Three U.S. scientific personnel are attached to the base.

Wilkes Station (Australia).—This station, which was formerly operated by the United States, is now operated under cooperative arrangements concluded with Australia. The scientific equipment and supplies were provided by the United States, and three U.S. scientists are present this season at Wilkes Station to carry on work in meteorology and biology. The remaining parts of the program—the same as under the IGY—are being carried on by Australian scientists.

Ellsworth (Argentina).—Cooperative arrangements with Argentina have provided for the continuation of the IGY programs in glaciology, auroral studies, cosmic-ray, ionospheric, and whistler measurements at this station. The Government of Australia is supplying all the logistics support for the coming year, and the United States has provided the scientific equipment and expendables. One U.S. meteorologist is assisting in the meteorological work only. The remainder of the scientific complement are Argentines.

Consideration has been given to enlarging the antarctic program to include an additional station at the Beardmore Glacier, the reopening of Little America or another station in this area to do meteorological work, the establishment of possible transportable stations for summer work in the unexplored areas of Antarctica, the procurement of an ice-strengthened ship to carry on extensive and thorough oceanographic studies in the waters around the continent, the conduct of a minimum rocketry program to broaden our understanding of the effects of the higher areas of the atmosphere on weather.

II. ARCTIC RESEARCH PROGRAM

The logistics requirements for the conduct of antarctic research have been such that highly coordinated efforts are necessary. As a general matter, however, the Foundation does not consider it appropriate to support scientific research on a geographical basis. Formal action has therefore not been taken to establish a closely coordinated research program in the Arctic in the sense as in the antarctic. Also, there has not been established an international organization for such a program. However, the Committee on Polar Research of the National Academy of Sciences has recommended to the National Science Foundation an Arctic research program for 1959–60, emphasizing those elements of the IGY program that they consider scientifically most important to continuing operation during future years. This recommended program is presently under consideration.

It should be stressed that many Government agencies are doing research in the Arctic as a part of their regular missions. All fields of science do not, however, receive equal attention. The National Science Foundation will, in all

probability, support scientifically sound research projects, particularly in those disciplines that do not at present receive adequate support from other agencies.

There follows a brief summary of Arctic activities during the IGY and their present status:

Arctic drifting stations

Station Alpha.—During the IGY the United States operated two drifting stations in the Arctic Ocean. Drifting Station Alpha, established on an ice floe, had a scientific program that included upper air and surface meterological observations, programs in micro-meteorology and sea ice physics, underwater sound propagation studies, seismic soundings, gravity measurements, magnetic observations, auroral studies, and several aspects of oceanography. Station Alpha was abandoned on November 7, 1958, due to deterioration of the ice floe. As many as 12 scientific personnel were engaged in the program at one time.

It is presently planned to establish Arctic Drifting Station Charlie, to be operated by the University of Washington and supported by the Office of Naval Research. It is expected that Station Charlie will be installed by June 1, 1959, and it is hoped to establish Station Charlie on an ice floe in the original location of Alpha (at about 75°, N, 155° W).

Station Bravo.—The second Arctic drifting station on Fletcher's Island (T–3) supported programs in surface meteorology, ionospheric physics, auroral studies, gravity and magnetic measurements, ice petrology, oceanography, and special meteorological projects. The Station has continued in operation to the present with a varying number of scientific personnel, up to 10 or 12 at one time.

Following the IGY Station Bravo has continued in operation with the support of the Air Force Cambridge Research Center.

Thule, Greenland

At the Thule Air Force Base during the IGY a comprehensive program in geophysics was carried out, including ionospheric studies, cosmic rays measurements, auroral physics, airglow measurements, seismic recordings, and geomagnetic measurements. Personnel for the Thule scientific investigations were drawn largely from the Air Force and the Army Signal Corps; civilian supervisory scientists paid frequent visits to the scientific establishment to insure its functioning.

The Army and the Air Force have continued their support of scientific operations at Thule; it is hoped that they will maintain the station at the same level as at present.

Alaska

University of Alaska.—At the Geophysical Institute, University of Alaska, in College, Alaska, the IGY program included intensive studies of all aspects of atmospheric physics. The program at College, Alaska, is presently in need of support, which several agencies are seeking.

Other Alaskan projects.—Other institutional projects carried out in Alaska during the IGY were closed down at the beginning of 1959. These included a chain of geomagnetic stations, a network of auroral stations, projects at the Arctic Research Laboratory in Point Barrow.

Fort Churchill, Canada

During the IGY Fort Churchill was the center for high latitude rocket investigations in the Northern Hemisphere. The planned program in rocket soundings there is terminating.

Exhibit J

Utilization of Weather Satellites

The National Science Foundation, as pointed out in exhibit G, has provided considerable financial support for the U.S. program of scientific activities conducted during the International Geophysical Year. On February 17, 1959, a meteorological satellite was put into orbit by the Vanguard rocket which was developed to launch earth satellites as part of the U.S. contribution to the International Geophysical Year.

The National Aeronautics and Space Administration is conducting a continuing program designed to launch a series of meteorological reconnaissance satellites of considerable payload weight and a capability of sustained performance in orbit (2 or 3 months) which will observe cloud cover and transmit to the

earth detailed information concerning such cloud cover. The Vanguard II cloud cover satellite just launched is their first in this series. New fundamental information on global cloud cover and distribution will develop from the satellite program and such information will be utilized in the weather research projects supported by the National Science Foundation.

Mr. FULTON. I am interested in the fact that you say that there is a limited field of scientists, when as a matter of fact we have scientists walking the streets looking for work in allied fields. Has there been a program of trying to develop much beyond just the schools that are specializing in this work now, the obtaining of scientists from allied fields who already know it? For example, I have been in the Navy Reserve, and I know a lot of fine officers that are in the fields of weather prediction in the services. Why do we not get those young men interested and get a program to that team over. As a matter of fact, I think yours is one of the most ambitious programs that we on this committee should be in. I am one who is shocked to hear that there is only $1.6 million programed when you have $3 million worth of projects. I think you have to go ahead because we in this country are looking to you as part of our defense, not only for our economy, but likewise for our defense on military. What if Russia gets ahead of us and controls the weather here before we can do anything about it or have countermeasures? You have not even spoken of the antimissile missile or the weather control missile. If Russia is working on weather control, which I believe they are—are they not working on weather control?

Dr. BRODE. I suspect they are.

Mr. FULTON. Suppose then they make the United States a desert within 3 years. What do we do then; we cannot do anything about it. Do we just accept it? I think you have a tremendous job. If nobody has given you that national security angle, I certainly think you should be working on that. I think it is a danger—and a tremendous danger—that Russia may by the use of storms, by keeping the rainfall from us, and by controlling the direction of tornadoes, cause us more damage than any atomic or nuclear weapon that she has, and all at once. The power per acre of one storm is what, 15,000 times the biggest nuclear bomb we have ever imagined and if she could unloose a power 15,000 times per acre with very little effort, possibly we better be doing something about it. I am shocked to hear there is no program on that. Is there? And that is the end. Is there such a program of defense against Russia on the weather tactics that she proposes?

Dr. BRODE. There has been a program of research in weather modification undertaken for some years by the Federal Government, among a number of agencies. I suspect we have probably spent around $5 million already on weather modification and it has not been easy to produce any substantial effect with this expenditure. It is something we have got to learn. We have learned that there are some things that can be done but they are not very substantial things.

Mr. FULTON. But you do not known what Russia is doing in this field of strategic weather control, do you?

Dr. BRODE. No, we do not know all of the things Russia is doing. I assume our Intelligence Agency is informed on some of these activities.

Mr. FULTON. But you have no relationship then with the Central Intelligence Agency at all, do you?

Dr. BRODE. No direct connection? We are supporting a program of experimental research in this country. As I was saying, the effects we have observed are definite but not large and if you would ask for an opinion as to whether very substantial effects like converting our climate from its present state to a desert climate, if they could be produced, I would say our evidence is that it will be extremely difficult if not impossible to make such a change. So although we spend money investigating the possibility, we would not be doing our full duty to the country if we did not ascertain as soon as possible the possibility of these things.

Mr. FULTON. In Pittsburgh in 1936 we had a flood in our area which cost us a half billion dollars and $1.6 million for the whole country is not much insurance against another flood, the tornadoes in St. Louis, or the floods occurring in Ohio, Indiana, or down the Mississippi to Louisiana.

Dr. BRODE. One thing you are suggesting and I think we should also say is it is quite possible and there are many scientists who have ideas with regard to proposals but that our budget here does not represent the maximum that could be spent.

Mr. FULTON. Do you know that the Russian weather ship is now in the Pacific on our Pacific missile range and has been there for weeks watching what we are doing under the guise of taking weather and sea checks and readings; did you know they had been there for weeks?

Doctor DROESSLER. The Russian oceanographic vessel.

Mr. FULTON. Yes.

Doctor BRODE. Yes, I visited that vessel when it was in San Francisco.

Mr. FULTON. Does that not alarm you a bit when they are visiting the Pacific and we have these programs going on?

Doctor BRODE. During the International Geophysical year, a 2-year schedule was laid out for this vessel and they are sticking to that schedule. They have made several surveys of the Pacific and they are covering the Pacific area now. As a matter of fact, they are in that area now.

Mr. FULTON. As a matter of fact, I know they are not on their schedule because they are waiting around the Hawaiian Islands now to take a group of scientists on a junket, on invitation, and it has not materialized yet. The question is, "Why have they not gone, why has it not materialized?" They are not on schedule, I disagree completely.

Doctor BRODE. I do not know about the recent changes in schedules, but the map I saw with dates and schedules when I saw the ship and talked with the officers there was in accordance with the program at that time.

Mr. FULTON. Well, I will check that, but I certainly know that they are waiting just to take a group of scientists on a junket and it has never materialized and they are just lingering in the area.

The CHAIRMAN. May I clear up something, Doctor? The $1.6 million which you spend on weather is not the sum total of all of the expenditures by the Government on weather, is it?

Doctor BRODE. No, it is not the sum total of our expenditures either. In addition to the weather modification program which you have

reported here, we have an atmospheric science program as well, the results of which of course bear directly on the knowledge of weather, our ability to predict and evaluate weather conditions.

The CHAIRMAN. How much do we spend on that?

Doctor BRODE. $1.2 million this year and $2 million next year is our proposal for that program.

The CHAIRMAN. Is it possible to find out, through you, what the different agencies of Government spend on weather, weather modification, weather control?

Doctor BRODE. We could provide you that information.

(The requested information is as follows:)

EXHIBIT K

Weather modification research being conducted by Federal agencies other than the National Science Foundation

[Information compiled by the Interdepartmental Committee on Weather Modification, January 1959]

Name	Location	Investigator	Title	Estimated amount for fiscal year 1959
Department of Agriculture:				
Project Skyfire	Missoula, Mont.	J. S. Barrows	Investigation of cloud modification techniques to the problem of lightning-caused forest	$75,000
Department of Commerce, U.S. Weather Bureau:				
National hurricane research project.	West Palm Beach, Fla.	R. R. Braham (University of Chicago.)	Hurricane cloud physics investigation.	[1] 53,500
	Washington, D.C.	D. B. Kline	Atmospheric ice nuclei observations.	15,000
	Missoula, Mont., Santa Barbara, Calif.		Cooperating in outside cloud seeding projects.	[2] 5,000
Department of Defense, Army:				
3-99-04-11	Army Research and Development Laboratories, Fort Monmouth, N.J.		Cloud physics and cloud modification.	15,000
3-35-15-4.2	do		Attenuation studies	15,000
Department of Defense, Navy:				
082-128	A. D. Little, Boston, Mass.	B. Vonnegut, C. Moore.	Thunderstorm electrification.	[3] 150,000
082-129	Cornell Aeronautical Laboratory.	R. Pelie	Freezing rain	15,000
NA 910-073	Naval Research Laboratory, Washington, D.C.	J. E. Dinger	Cloud physics studies using carbon black, Project Blackbody.	50,000
Department of Defense, Air Force:				
7605	Geophysical Research Directorate, Cambridge, Mass.		Weather modification-dispersion or prevention of low clouds and fog at airfields.	75,000
6697	do		Stratus and fog dissipation for operational support of transport and cargo aircraft.	[4] 100,000
7695	do		Contrail suppression	50,000

[1] Aircraft and its support not included.
[2] Plus loan and transfer of equipment.
[3] Including NSF partial support.
[4] Planned.

The CHAIRMAN. One more question to clear that up.

Mr. FULTON. Right on that point, Mr. Chairman, could you capsulize the programs of the various agencies, list them, and show how they interrelate to each other, to get the whole picture as the chairman has suggested, not just the money but give us the program?

The CHAIRMAN. I think we are going to have to hear from some of the other departments on their own program, but give us what you can. Now one more question just to clear up something. Have we reached the point in weather control where we should think about entering into international agreements regarding the future control of the weather, so that one country would not steal the rain from another country and one country would not make another country arid, have we reached that point where we ought to give that thought?

Dr. BRODE. I think we should be continuously conscious of the possibilities but my present assessment of the feasibility of such radical weather control as that is that it will not be accomplished in the near future and that we have plenty of time to work into this program. Of course, the problem is not only international but interstate. There would be States that would be worried about taking water away from the next State.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Doctor, as I understand it, your present program now, and you have spoken about three conferences, one of them is to study and gather some statistics on the type of weather, and the next thing is what can we do after we have determined what the weather is, when the clouds come over what we can do either to cause the rain to fall or not to fall or to modify it, is that correct?

Dr. BRODE. Yes.

Mr. MILLER. Now I am interested in this because I realize it is important, but again this is the first opportunity we have had to see anyone from the National Science Foundation. The National Science Foundation is not simply concerned with control of the weather. It covers the whole spectrum of science, does it not?

Dr. BRODE. Yes.

Mr. MILLER. And all fields of science. This is the place that we look now to coordinate scientific programs. Could you tell me what you are doing in the field of oceanography? In other words, I am very much concerned when I read in the public press that the Russians have launched or have established on our coast beacons that can guide their submarines. I see if they can get to our coast this can be a very simple and a very effective way of establishing themselves. Are we doing anything in the field of studying the ocean or the body of the ocean, that beneath the surface, that would help us—just as this weather modification would help us—in our economy and also as part of a defense effort? Has the National Science Foundation any programs in that field?

Dr. BRODE. Yes, we have been supporting this year about a million dollars worth of oceanographic research. We are concerned primarily with basic research according to the restrictions of our act and applied research programs in this area have been carried out by the Navy in a very substantial way. The basic research work, however, we are entering in a more vigorous way. Next year's budget proposes two million for research and two million for an oceanog-

raphic vessel in our National Science Foundation program. So we are enlarging our support in the oceanographic program which is close to this morning's testimony since there is a close connection between ocean currents, ocean information, and weather, at the same time.

Mr. MILLER. Now we realize, although weather has been with us a long time and we have not done very much about it, there is not very much we can do. It is one of those things where we cannot go in and just by dumping money—giving a group of scientists a lot of money—and saying come out and change weather and stop storms from ravaging the country or hail from destroying the grain in Nebraska—get the desired results, is it? Are any of these programs done that way?

Dr. GUSTAVSON. I think you have put your finger on something very important and we should be thinking about it. It was my privilege to be at the University of Chicago and organize the Institutes of Nuclear Science there. I once asked Enrico Fermi what was the maximum amount of money you ever had in any year for your research at the University of Rome. He said about a thousand dollars. Now it was that basic experiment or series of experiments of Fermi which started this whole series of experiments and efforts in terms of nuclear energy. Next came a breakthrough from Otto Hahn in Germany. Then we have a basis for work. One of the very fundamental problems here was to isolate the element that was formed when uranium was bombarded by neutrons. Now this was not solved by crash programs all over the world, gentlemen. This was solved by a brilliant young scientist from the University of California, Glen Seaborn, who isolated infinitesimal amounts of plutonium and gave us its properties. It was the skilled work of one individual surrounded by many, of course, that gave you the breakthrough. At this stage of our work, attacking these fundamental problems on weather modification the quality factor must loom high in the kind of work that we try to do.

Mr. MILLER. In other words, we can make the progress now if we give you enough money and support you so you can have continuous programs in the basic research, in the field of weather, in the field of oceanography, in these great mysteries that we do not know too much about—this matter of ocean currents. We know once upon a time Napoleon conceived the idea if he could build a dam between the tip of Florida and Havana, he could starve out the English Isles, but he did not know too much about ocean currents. As one, not a scientist, but formerly an administrator with scientists under me, I am quite surprised at what has developed now as to ocean currents, that as late as 10 years ago we did not accept or know. Has there not been a great development in that field, too?

Dr. BRODE. With more measurements we are finding out a great deal more about the properties of the ocean. The streams are not all on the surface. There are undersurface currents moving in opposite directions which are important carriers of heat, energy, and material.

Mr. MILLER. I know. I used to be executive officer of the California Division of Fish and Game and we now find pelagic fishes, which we thought only swam on the surface, follow some of these currents down and show up in different places. It has a lot of people confused.

I want to congratulate these gentlemen, Mr. Chairman. I think the National Science Foundation is doing a great job. I think we

get impatient with it because we think we can buy programs. The greatest service we can give them is to support them and make sure they have enough money for their basic research—when they get into their basic research, when they begin to get the breakthrough be sure we give them enough money then—but not to expect the impossible. They are human, as we are.

The CHAIRMAN. Any further questions? Mr. Anfuso.

Mr. ANFUSO. Doctor Brode, in the President's report issued on February 2, on page 9 this statement is contained:

> Future weather control satellites can be expected to provide far-reaching benefits besides improving day-to-day forecasting; meteorologists may be able to predict droughts and rainy spells a year or more in advance. The value of such information to farmers is beyond estimation. Hurricanes and tornadoes could be spotted and their deadly paths predicted.

Now, as a former farmer, I am interested in that. How long in advance, for example, can you spot a hurricane or a tornado? Just now you are dealing with the atmosphere, but assuming you could trace a hurricane in advance, how much warning could be given to farmers, et cetera, or to ships at sea?

Dr. BRODE. You are, of course, aware that we do spot hurricanes and tornadoes in advance and they follow up the coast, with their alphabetical names, and we know where they are coming in and we are given some warning on this. The program of the weather control satellite is perhaps a misnomer in the sense one will not control the weather with the satellite but it is an information agent, a mapping agent which gives you a picture of the clouds over the whole surface of the earth and it is hoped that with information from the cloud distributions, and from pictures on successive runs of the satellite over the earth's surface, you will get the motion of the clouds, and from this you will be able to see all of the winds on the surface of the earth and the cloud distribution as they are changing.

Mr. ANFUSO. Can you now, Doctor, trace its origin; do you know where it begins?

Dr. BRODE. We have rough ideas where hurricanes begin, but we have to have a detectable atmospheric phenomenon in order to detect the beginning.

Mr. ANFUSO. It might originate from the beginning of the atmosphere. You may have to go into outer space to find that out. Is that not possible?

Dr. BRODE. It is not probable that the hurricanes begin from some motion imported from outer space to the top of the atmosphere, because the density of the layers there is very low. We know already that there are very high velocity streams, jet streams at high altitudes in the atmosphere. It may be that something is carried over from some of these high velocity streams that starts the impulse that begins the hurricane motion.

Mr. ANFUSO. How much warning do you now have of a hurricane or a tornado?

Dr. DROESSLER. The hurricane is a weather phenomenon that has a life period of days, from 3 or 4 days up to 10 days or more. With the hurricane reconnaissance activity of the Air Force and the Navy, the U.S. Weather Bureau is giving warnings of up to 2 or 3 days in advance of hurricane activity that might influence any part of our eastern shore.

Mr. ANFUSO. That is as far as you can go now?

Dr. DROESSLER. Yes, on hurricanes.

Mr. ANFUSO. Do you foresee the time when you might be able to forecast that, say a week or more in advance?

Dr. DROESSLER. We have the hurricane season tied down. We know hurricanes occur between June and September. We also know when hurricane conditions are about, through our weather maps that are drawn, the surface weather maps and the weather maps that display weather phenomena at different elevations in the atmosphere and also because of our hurricane reconnaissance planes we can tell when incipient hurricane conditions have arrived. So, on the hurricane itself I think—well, we do quite well, because it is a weather phenomenon that persists over several days. You touched on the tornado and that is quite a different kind of weather phenomena. It is perhaps our most severe storm activity. A tornado in reality is a large thunderstorm, a very large thunderstorm. Just why it goes into tornado conditions is still unknown by meteorologists. A large thunderstorm or tornado is a weather phenomenon of a couple of hours, therefore, the best we can do today is to forecast tornado conditions over an area and when or where they will strike in this area, no one knows. It is only a matter of hours of warning that could ever be given on a specific tornado situation.

Mr. ANFUSO. There is a lot more research that can be done in that area.

Dr. DROESSLER. Oh, very much more.

Mr. MILLER. Where does a typhoon come into the picture?

Dr. DROESSLER. That is simply a hurricane in the Pacific.

Mr. ANFUSO. When you find a little more about that you might be able to divert a storm, is that right?

Dr. DROESSLER. That is certainly one of the hopeful areas which we can have as an objective, to be able to divert a hurricane. That would certainly be one of the objectives we have in mind.

Mr. ANFUSO. Then you could stop some of the things the chairman has been talking about and also those Mr. Fulton has spoken of in his State, is that not right?

Dr. DROESSLER. Also another objective of weather modification is to suppress the tornado.

Mr. ANFUSO. Now, I am interested in this cloud seeding. Are you confined at the present moment to experimenting within the continental limits of the United States?

Dr. BRODE. No, we are not confined to that limitation. We have evaluated the programs we can get hold of from other countries. You will find in the report of the Weather Control Committee evaluations of the seelings done in France where similar activity is undertaken.

Dr. ANFUSO. Which is done by France?

Dr. BRODIE. Done by France? I believe this year there is an international Conference on Cloud Seeding, is there not, Dr. Droessler?

Dr. DROESSLER. Yes, the Italians also have a cloud seeding effort going on now. It is a hail suppression project in the northernmost part of Italy, designed to see what they can do about suppression of the hail that is very damaging to the tobacco crops in that area. There is an International Conference on Cloud Physics and Weather

Modification that is tentatively being planned for September of this year. The locale will be Italy.

Mr. ANFUSO. Now, have you any knowledge as to whether or not any cloud seeding is being done in desert lands like in Asia or Africa?

Dr. BRODE. I should probably correct something of a misapprehension with regard to cloud seeding. Most of the efforts in cloud seeding are in areas where the conditions are such that it is probable you will get some increased activity from the rainfall. In other words, we try to augment the rainfall. We do not at the moment undertake programs in which we are attempting to make it rain in the Mohave or the Sahara Desert where it just does not rain. Where you have cloud formations with moisture present, we make efforts to wring some of that moisture out of the clouds but if there is very little there it would take substantial more effort than we are prepared to do at the present time to make it rain.

Mr. ANFUSO. That is what I am getting at. Is it possible to divert weather conditions so we can bring rain to these desert lands?

Dr. BRODE. This I am not able to say at the present time. We must make more experimental studies in regard to this problem.

Mr. ANFUSO. Is any country doing anything along those lines?

Dr. BRODE. No; not that we know of. I think they are more working on the immediate problem of trying to increase precipitation from clouds; that is, finding out what can be done with clouds that exist. Then we will go to the problems later where there are not any clouds.

Mr. ANFUSO. Do you think it important that work be done along those lines?

Dr. BRODE. Yes; I think it would be extremely important if you could provide rainfall in desert areas.

Mr. ANFUSO. Do you foresee that doing work along those lines might make lands fertile and thus bring about a world of abundance so that no country need be in starvation?

Dr. BRODE. Well, if you can modify the weather that much, you could do so, but this would be a very rash prediction at the present time with the information that we have.

Mr. ANFUSO. Now in this field, this very important field—and I agree with the chairman, Mr. Fulton, and my colleague from California, that it is a most important field—do you regard international collaboration and cooperation as being extremely important?

Dr. BRODE. Yes; I think international collaboration and cooperation is very important. There has been some indication of the possible impact of this as an offensive weapon. I think there is more to be gained by thinking of this as a weapon of civilian value to the world, as a method of improving world conditions, and it will be in the long run.

Mr. ANFUSO. All this that I am talking about is on the constructive side. Do you foresee in work of this kind where it will more than pay for itself?

Dr. BRODE. Yes; I think if you can increase the rainfall 10 or 20 percent in an area, water is worth a great deal, and this pays for itself.

Mr. ANFUSO. Now do you regard it as so important that we have a continuous program to encourage, train, and educate youth to become scientists?

Dr. BRODE. Certainly that is an extremely important program.

Mr. ANFUSO. Now this has been touched upon, but I would like to elaborate upon it a great deal or a little more, if I may. Isn't there a possibility that in the control of weather we can likewise control or make less effective destructive missiles in the air? We can knock out of range their calculations, for example?

Dr. BRODE. This depends on how clever you are in your own devising of controls and devices. A missile with internal guidance is not easily diverted from its path.

Mr. ANFUSO. For instance, all of the calculations that are presently being made are with the existing knowledge of weather conditions. Do you foresee any change, any possibility of change in those weather conditions to knock out of gear these calculations?

Dr. BRODE. I don't foresee an immediate usefulness in weather modification as a defense against missiles.

Mr. ANFUSO. Someone said—I don't recall now, but I did see an article—that if you can control the weather, you can control the world, and you can knock out of gear all of these calculations that are going on about us, intercontinental missiles and so forth. Do you see any possibility of that as a scientist?

Dr. BRODE. I can certainly say that if you control the weather, you certainly will control the world, but not through diverting missiles but simply through impoverishing or flooding the areas that need it.

Mr. ANFUSO. Which is very, very important.

Now then, in other words, you think we ought to go full speed ahead on that kind of program; isn't that right?

Dr. BRODE. I think we should undertake a substantial research program in this area. I would not feel that we can say with sufficient certainty that this is the program of the most importance which will yield us the greatest control or knowledge of nature and the world at the present time. There may be other areas we should devote some activity to. The area of oceanography is one. Someone earlier mentioned that the Foundation is responsible to the Government for basic science research in a great many areas, and this is one in which we believe a substantial activity should be undertaken.

Mr. ANFUSO. I have one more question.

The CHAIRMAN. All right. Because we have to get around to the others and give them a chance, too.

Mr. ANFUSO. All right, go ahead.

Mr. HECHLER. Dr. Brode, you talked a little this morning about the value of weather satellites possibly leading to weather control. I am concerned about the organization on this interdepartmental committee. Are the Defense representatives on this committee merely there to report their activities or can you really get your teeth into this and get in your bid as to what you would like the Defense agencies to do in respect of their own satellite programs?

In asking this question, I am referring not to the activities Dr. Droessler has discussed, as to what is going on at Woods Hole and things like that, but particularly in reference to the satellite and similar programs of the Defense agencies.

Dr. BRODE. The Foundation is by its act given some responsibility for correlation of the research science activities of the various agencies of the Government, but it has no teeth in the sense that it can

make any agency undertake a program or discontinue a program. It is largely a matter of getting people together and discussing the programs and getting them to realize where there is duplication or missing areas of activity that should be encouraged.

This is our present authority, getting people together and trying to develop coordinated programs.

Mr. HECHLER. How do you feel about this personally? Don't you feel when a program deserves priority you should have the authority to bring it forcibly to the attention of the agency which is conducting it?

Dr. BRODE. We have the opportunity to bring it to the attention of the agency, and the Director can in such cases communicate directly with the Secretary of the agency, pointing out this duplication, and seek to obtain through consultation with him some adjustment.

Mr. HECHLER. You wouldn't feel, then, you should have more authority? When you feel something is very important to the national security or very important for particular scientific development of information on weather, don't you have to have sufficient teeth to see that it is carried out?

Dr. BRODE. I don't think we need the teeth to carry this out, because I think there are agencies which can do that.

The new Science Research Council, set up by the President, will have some authority, and the National Science Foundation is represented there, so it will be possible for us to bring to the heads of agencies directly the questions that need an executive order to effect the removal of duplication and waste.

Mr. HECHLER. I would only add this:

This committee would certainly be interested in the projects which you would consider to be of high priority, which come under the jurisdiction of other agencies, and which other agencies are not pursuing with urgency.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. McDonough.

Mr. MCDONOUGH. Mr. Brode, I am quite interested in the cloud-seeding experiments.

Coming from California, as you know, water is a very vital thing to us, and we are seeking every possible source to supplement our supply and to maintain whatever supply we have.

I am the coauthor of a bill, together with several other western Congressmen, for an intensive operation in cloud seeding in the upper Colorado River Valley, especially since we are now developing the upper Colorado with several dams which will divert the flow of the Colorado River.

I don't know whether that will come under your jurisdiction or not, but are you in your cloud seeding contracting this work out or do you perform the services yourself—your agency?

Dr. BRODE. The National Science Foundation is in its activities not an operating agency, but we make contracts and grants to have work done, and we have made arrangements for various cloud-seeding operations.

Just this morning, as I was sitting at this table, I saw for the first time a copy of the bill you were talking about.

So we really haven't had an opportunity to study this proposal, but as you say, you are proposing an operational bill, and the work of the National Science Foundation has been largely in study, research, and evaluation. We believe, of course, that this precedes operation; that before one goes into an operating program, one goes into a program of study, research, and evaluation, and one will have to look at the data that are available in the area that you are proposing operational activity.

If you are seeking any advice as to whether this is an appropriate measure at this time, it would depend upon what evidence exists, what research and study and evaluation has been made in this area.

Mr. McDONOUGH. What is the most effective element used in cloud seeding to promote rain in a known clouded area that can be tapped?

Dr. BRODE. I believe silver iodide is the usual agent.

Mr. McDONOUGH. It is the most effective agent we know now?

Dr. BRODE. Apparently as effective as is known.

Mr. McDONOUGH. Dry ice has also been used.

Dr. BRODE. Yes.

Mr. McDONOUGH. At what elevation do you seed those clouds? Do you go to wherever the clouds are; do you go through the clouds and seed or do you go above them?

Dr. DROESSLER. The silver iodide can either be put into the clouds from aircraft or wafted up into the clouds from ground generators. The silver iodide, in order to become effective, must reach the cloud level above freezing, because the essence of silver iodide seeding is to convert supercooled water droplets—that is, small water droplets that are in a temperature below freezing—convert them into ice crystals. These little ice crystals will grow large, at the expense of other water droplets around, and drop as snow.

Mr. McDONOUGH. Is it the hydroscopic characteristic of the silver iodide that develops the rain?

Dr. DROESSLER. No; it is thought that the mechanism involved is that the silver iodide crystal structure is very closely related to or very similar to the crystal structure of natural ice, the hexagonal crystal, and therefore in effect nature is fooled into depositing moisture on the surface plats of the silver iodide crystal, just as she would if they were natural ice crystals.

Mr. McDONOUGH. In other words, you shoot the silver iodide into the area where you think there is the moisture, which creates ice, which in turn drops to a level where it melts and creates rain?

Dr. DROESSLER. Right.

Mr. McDONOUGH. And you can disperse this silver iodide into the atmosphere by shooting a bomb or what? How do you get it up there?

Dr. DROESSLER. In your State of California, Mr. McDonough, the moisture-bearing winds usually come off the Pacific Ocean and are forced to rise when they come in contact with the mountains. If you put the silver iodide in at the coastline from ground generators as a smoke, it will just rise into the moisture-laden winds as they go up higher in the mountains, where the moisture condenses, forming clouds, and rain, or snow.

Mr. FULTON. Would you yield to me?

Mr. McDONOUGH. Yes.

Mr. FULTON. We, in clean Pittsburgh, would like to know what you can do to help Los Angeles.

Mr. MCDONOUGH. We are talking about rain, not smog.

Is it possible to disperse a hurricane with a small atomic bomb if you hit the eye of the hurricane?

Dr. BRODE. The experiment has not been done. I rather doubt that it is possible.

Mr. MCDONOUGH. Has it ever been thought of and has there ever been any theory advanced on it?

Dr. BRODE. It has been thought of, but as the remark was made here earlier, the actual energy in an atomic bomb is not very great compared with the energy from the sun. The atomic bomb is remarkable in the amount of energy that is released in a short time, in a fraction of a second, but the total energy there is not large compared with what is falling in sunlight on a few square miles.

Mr. MCDONOUGH. You mean the centrifugal force of the eye of the hurricane is so great the bomb would not disturb that?

Dr. BRODE. Yes, the total energy involved in hurricanes is large compared with the total energy in an atomic bomb.

Mr. MILLER. What would happen to the fallout if you shot a bomb into a hurricane and the winds get up there?

Dr. BRODE. It would be spread over a good bit of the earth.

Mr. MILLER. The cure may be as bad as the disease.

Dr. BRODE. That could be.

The CHAIRMAN. The fallout comes from the debris over the earth. Most of that would be over the ocean.

Dr. BRODE. The fallout is the radioactive material in the bomb itself. It can be augmented if it is exploded near the surface of the earth, so as to activate ground material, but from a high-level explosion it would come from the material in the bomb itself.

Mr. MCDONOUGH. Is there any known power that can be used to hit the eye or cone or source of the hurricane to disperse it?

Dr. BRODE. Not to my knowledge.

Mr. MCDONOUGH. What do you know about this announced warming period that the earth is passing through at the present time? Is this a cycle we go through or is it something new?

Dr. BRODE. It is a cycle which we go through. There have been long-term weather observations, and there are various scientific methods of even carrying weather and temperature back for many millions of years in cycles. We know from our geological surveys that we have gone through glacial periods and tropical periods on the earth, and it is not at all surprising that in periods of centuries temperatures will change.

Mr. MCDONOUGH. Does this warming period mean that the icecap will melt more rapidly and a greater supply of water will be thrown into our lakes and rivers?

Dr. BRODE. What happens is a complicated picture. Whether the carbon dioxide content will change the rate of absorption of energy from the sun, it is difficult to say. It could result in more rainfall. It could result in just the opposite.

Mr. MCDONOUGH. That is all.

The CHAIRMAN. Could I ask a question in reference to the same situation?

Have you ever been able to set up any definite figures to show in what percentage of cases cloud seeding is effective and when it is not effective?

Dr. BRODE. I would refer you to the report of the Weather Control Committee, Mr. Chairman, set up by Congress, which does report that in the Mountain States of the western United States their statistics indicate between 10 and 15 percent increase in rainfall in the seeded storms.

The CHAIRMAN. In each one of them? Or what percentage do you have that increased?

Dr. BRODE. They studied some 200 or 300 storms, or passage of clouds.

The CHAIRMAN. Each one of 200 or 300 storms showed an increase?

Dr. BRODE. No, that would mislead you if I said that. Some showed a decrease. But on the average it was an increase.

The CHAIRMAN. What do you deduce from that as the percentage of effectiveness?

Dr. BRODE. The average, the percentage of effectiveness—in some cases you would get 50 percent increase, in some cases a decrease, but the average was between 10 and 15 percent.

The CHAIRMAN. We had a cloud seeded in my hometown several years ago, and it increased the rainfall to such a point they had to look around and find some means of stopping it.

Dr. BRODE. I would say that it was an exceptional phenomenon.

The CHAIRMAN. That is exceptional?

Dr. BRODE. Yes.

THE CHAIRMAN. But you feel it is reasonably effective, even to the point that a municipality might spend money in order to create rainfall and justify that expenditure?

Dr. BRODE. If you consider 10 or 15 percent increase of value; on the average, that is what you may get, if it is done in the area of the United States where this data was taken and with the kind of storm clouds the data was taken for.

The CHAIRMAN. You read that article in this morning's paper about the warming up of the world.

Do you agree with the contents of it?

Dr. BRODE. I think it is good scientific data; yes. I think this is an observation which is indicated by our evidence at the present time. It isn't coming very fast. It is slow.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Do we have presently in existence any balloon program gathering weather information over the U.S.S.R., itself, Doctor?

Dr. BRODE. I don't know of any balloon program over the U.S.S.R. for weather information. They do fly their own weather balloons for upper air temperature and currents, measurements, but we have no program that attempts to secure that additional information.

Mr. DADDARIO. Thank you.

The CHAIRMAN. Mr. Wolf.

Mr. WOLF. Mr. Chairman, gentlemen, I am Leonard Wolf from Iowa, and it loks like I represent the great Midwest here.

We are terribly interested in tornadoes and the effects they have had on our economy in the Middle West. It is not only Iowa but Kansas and Missouri as well.

I think you said we normally have about a 2-hour warning ahead of tornadoes. The day that I left Washington, a few days after the election here—I think around the 15th of November—they had one in my hometown which had less than 30 minutes' notice. It could have been terribly devastating to human life. It hit right in the busy time of day, when the children were leaving the school, and the strange thing is that there was only one woman, looking up at the top of a building, hit on the head by a brick, yet it hit the very center of the commercial district of our village, and it was very devastating.

What I am interested in is: What direction is your research on tornadoes going? I think you said you can't disperse these tornadoes by any known means at this time, and you have no research working, apparently.

Would a space satellite, a weather satellite, give us a little increased warning? It would take more than one, I know, because this was a very closely centered thing. It actually hit only this one town in Iowa, and then dispersed.

Would radar equipment in a space satellite give us any help in that respect?

Dr. BRODE. I would say, generally, our ability to predict weather changes and weather phenomena will increase with more information and the establishment of a weather survey satellite, a cloud survey satellite that gives us the additional worldwide pattern of clouds and their distribution and velocities is additional information that will help us in the general problem of prediction of weather phenomena. An increase of the data gathering in the country, through the Weather Bureau stations, an improvement in the use of our existing information through better use of high-speed computers which will integrate the data—these all will help in building up pictures of what is the predicted weather conditions. As Dr. Droessler said, at the moment we are somewhat limited as to the point of being able to predict what the climate or the weather is in the period when hurricanes or tornadoes are likely or probable. We can give that kind of warning, but we have difficulty in giving precise information.

Dr. Droessler.

Dr. DROESSLER. The tornado is a weather phenomenon that has a life cycle of just a couple of hours. So we have the possibility of giving warnings up to that amount of time. But that doesn't mean that we can give them today. Our best method of knowing where an individual tornado is at this time and where it might go, comes from looking at the tornado with radar. So our best bet today and how to improve the ability would be to expand the Weather Bureau's radar network. The radar can pick up a forming tornado. You can then track the tornado by radar and you can deduce from this where it may eventually go.

Mr. WOLF. Theoretically they could watch a tornado better from above than from surface radar?

Dr. DROESSLER. The surface radar works well.

Mr. WOLF. I live in a hilly section of Iowa. A lot of people don't think there are hills in Iowa, but there are.

I was wondering if there would be a problem here with rolling country.

Dr. DROESSLER. With modern radar looking out 50 to 100 miles, the local topography doesn't usually hamper it in a serious way. You can usually get around that by fixing the radar at a high enough elevation. I happen to be from Iowa, too, Mr. Wolf.

Mr. WOLF. Fine.

The other question I thought, not particularly facetious but in a humorous vein, is do you hold out any promise for the people of Oswego, N.Y., for next winter to stop the 60 or 70 inches of snow?

Dr. BRODE. Well, lightning doesn't strike twice in the same place.

Mr. WOLF. It is a real problem.

Thank you, Doctor.

The CHAIRMAN. Any further questions?

Doctor, may I ask you a question or two, then, if there are no further questions?

I want to ask you about the use of the Doppler system in reference to tornadoes.

How effective is that system?

Dr. BRODE. Radar gives location. Doppler radar gives velocity at the same time.

The CHAIRMAN. Can you effectively tell the velocity of the wind in the tornado?

Dr. BRODE. You can tell the rate at which the moisture is moving. The radar has to be reflected from something, and it is the mass of air containing the water vapor that will give the reflection. You can tell the velocity and direction in which it is moving.

The CHAIRMAN. At what velocities can you clock them, or have we clocked the tornadoes?

Dr. DROESSLER. I am trying to remember reports I heard just several months ago when attending the Radar Weather Conference at Miami, and I believe the Weather Bureau's radar, a Doppler system, in the Midwest has recorded velocities up to 200 miles.

The CHAIRMAN. That is tornadoes?

Dr. DROESSLER. In a tornado; yes.

The CHAIRMAN. I have heard it said velocities reached as high as 500 miles an hour.

Dr. DROESSLER. That is correct.

The CHAIRMAN. But they haven't checked them on the Doppler system yet?

Dr. DROESSLER. No; they haven't.

The CHAIRMAN. How does that compare with the velocity of wind in a hurricane?

Dr. DROESSLER. It is much smaller in a hurricane. Of course, the hurricane winds are spread out over a greater area, but the hurricane winds seldom exceed 120 miles an hour.

The CHAIRMAN. There is a greater mass, though, in the hurricane than in the tornado?

Dr. DROESSLER. Yes; the tornado high winds, in hundreds of miles per hour, extend over the distance of perhaps a city block, whereas the hurricane severe winds will extend from the center out several miles to hundreds of miles.

The CHAIRMAN. The tornadoes travel usually from southwest to northeast. Why is that?

Dr. DROESSLER. This is the prevailing wind direction.

The CHAIRMAN. So they drift along with the air currents?

Dr. DROESSLER. Yes, sir; they drift along with the air currents that move the cloud. These clouds are imbedded in large layers of the atmosphere, and the winds between about 5,000 and 15,000 feet over the tornado belt are generally moving from the southwest to the northeast; therefore, the tornadoes move in that direction.

The CHAIRMAN. As a rule, the tornadoes do come mixed up with moisture clouds, don't they?

Dr. DROESSLER. Very much so.

The CHAIRMAN. Heavy precipitation?

Dr. DROESSLER. Yes.

The CHAIRMAN. Down in the lower Mississippi Valley we spend about $70 million a year for the handling of flood control and stream control, the water problem there.

Now, in line with the questions asked by my colleague, Mr. Fulton, if we have to spend that amount of money, couldn't we by control of the weather save a great deal of those expenditures?

Dr. BRODE. If we could properly control the weather, we would certainly save tremendous amounts of money, but I think the scientists would not be the first to urge extremely large expenditures until we have been able, through research, study, and evaluation, to give you a better assurance that your money will be well spent.

The CHAIRMAN. In other words, you are unwilling to take the hazard of increasing the program until you can definitely see better results?

Dr. BRODE. We are willing to increase our program perhaps more than this indicates, but we would like to do it in a systematic and scientific way so that we can be somewhat confident of the results.

The CHAIRMAN. Because, as I say, we spend just about a billion dollars a year on water problems; the U.S. Government does spend that. If there was a way of handling this problem, you could reduce the amount of expenditures by the Federal Government considerably. Therefore, if more money is given to you for the handling of this program of scientific development, you might easily show an actual saving to the U.S. Government in its own expenditures; that is correct, isn't it?

Dr. BRODE. That is correct.

The CHAIRMAN. Any further questions?

Mr. ANFUSO. Do we have any more witnesses for this morning, Mr. Chairman?

The CHAIRMAN. These are all we have this morning.

Mr. ANFUSO. Then may I ask another question, Mr. Chairman?

The CHAIRMAN. Yes; surely.

Mr. ANFUSO. Dr. Brode, did you read Captain Orville's book? He is a former Navy captain.

Dr. BRODE. I have read parts of it, and I read the article in the Saturday Evening Post.

Mr. ANFUSO. I think that is the article I had in mind.

Do you agree with the conclusions he arrived at; the forecasts he made?

Dr. BRODE. Personally, I think he is a little optimistic on time scales and total effect to be achieved in a reasonable time by our studies.

I think we should approach this matter in a scientific and careful manner. We should be bold enough to do the experiments rapidly and

attempt to get results, but I think we would be misleading people if we would try to persuade them that this was going to produce terrific changes in a short time.

Mr. ANFUSO. Is he dealing in possibilities which may become probabilities?

Dr. BRODE. Well, he is dealing in imagination to some extent.

The CHAIRMAN. Any further questions?

If not, Mr. Ducander, do you have any questions?

Mr. DUCANDER. No, sir; not at this time.

Mr. FULTON. May I make a statement?

The CHAIRMAN. Mr. Fulton wishes the opportunity of putting a statement in the record; if there is no objection, so ordered.

Mr. FULTON. I would like to have them put in a statement, if they will, on this Russian oceanographic and weather ship that is now in the Pacific, that is in our Pacific missile area and likewise near the atomic and nuclear experiment area.

I would like to know what you know about it.

The ship's name is *Vityaz*. And what its schedule is, which you have heard about, and what its scientific purposes are.

I am not suspicious, but I would like to know why it is hanging around, and I would like to have a scientist do it impartially.

The CHAIRMAN. If there is no objection, that statement will be put in.

(The requested information is as follows:)

EXHIBIT L

PURPOSES AND SCHEDULE OF THE RUSSIAN OCEANOGRAPHIC VESSEL "VITYAZ"

In October 1958, the National Science Foundation received from the U.S. National Committee for the IGY, copies of exchanged corespondence between the committee and the Soviet IGY Committee concerning plans for the U.S.S.R. vessel *Vityaz* to call at the ports of San Francisco and Honolulu, including the general invitation extended to U.S. scientists to visit the ship while in port. The U.S. National Committee for the IGY wrote a routine letter of welcome to the Soviet IGY Committee in regard to the visit, which was first cleared with the Department of State.

The Soviet oceanographic vessel *Vityaz*, at the time of her call at San Francisco in December 1958, proposed upon her departure to proceed southeasterly to 30° N. latitude, thence westward to about 137° W. longitude, south to 25° N., east to 115° W., southeast to 110° W., and west along the 20° N. parallel to Hawaii, ariving on February 3, 1959. A slight deviation was made from this course at 20° N., 120° W. in an unsuccessful attempt to locate the Allaire Bank. While in this area daily weather and position reports were broadcast by radio.

The purpose of the present *Vityaz* cruise is to continue the investigations in physical, chemical, and biological oceanography that she conducted during three previous IGY cruises. Oceanographic temperature and salinity data have been turned over to the Scripps Institution and copies of their bottom soundings have been given to the Navy. Data is also being sent in by the *Vityaz* to the World Data Center for the IGY at Texas A. & M. University. There has been no indication that any of the relatively minor deviations from the schedule of the *Vityaz* have been for other than scientific reasons.

Attached is a copy of an article on this subject which appeared in Science magazine of January 2, 1959.

SOVIET RESEARCH SHIP VISITS UNITED STATES

The first visit of a Soviet scientific vessel to the continental United States during the International Geophysical Year occurred on December 17, when the *Vityaz* arrived at San Francisco. Representatives of the National Academy of Sciences greeted the Soviet scientists and crew, who have been engaged in oceanographic studies in the Pacific as part of the IGY program.

During its IGY voyages, the *Vityaz* sounded a record depth in the Pacific of 35,948 feet, off the Philippines in August 1957; discovered a 20,340-foot depression in the ocean floor north of the New Hebrides Islands; and brought to the surface from depths of 35,000 feet several previously unknown species of sea animals.

Scientists who visited the ship when it docked at Vancouver, British Columbia, in November report that it is extremely well equipped for a variety of oceanographic work. Approximately 65 scientists and a crew of about the same number are on board, including about 35 women. Chief of its scientific party is Nikolai Sysoev, whom many U.S. scientists met in Moscow last August at the Fifth General Assembly of the World IGY Committee.

The Soviet Government indicated in advance that the *Vityaz* would be open to visit by American scientists and other interested persons while she was in San Francisco, and later in Honolulu, and that arrangements for such visits should be made with the ship's authorities after her arrival. The National Academy of Sciences' IGY Committee asked John Lyman, a member of the U.S.-IGY Committee's panel on oceanography, to make arrangements for theses visits and for visits by the Soviet scientists to American scientific research facilities and institutions. Scientists from the University of California at Berkeley, the Scripps Institution of Oceanography at La Jolla, the U.S. Navy Hydrographic Office, the U.S. Coast and Geodetic Survey, and representatives of other interested institutions went on board the vessel.

The *Vityaz* is one of 13 Soviet ships participating in the IGY oceanography program, 9 of them being primarily research vessels. Including the U.S.S.R., 25 nations are engaged in IGY oceanographic work, using a total of approximately 70 vessels. Of these, U.S. institutions account for eight.

The CHAIRMAN. Before we adjourn, I would like to say this is the first opportunity we have had as a regular standing committee of the House to have representatives of the National Science Foundation before us.

Now, at a later date this committee would like to know just what is the overall budget for the work of the National Science Foundation. We want to see where it is going, where we can be of assistance to the National Science Foundation, and we would like to have therefore some frame of budget indicating the projects that are being considered and the emphasis being placed on those projects.

So if you would take that information back, Doctor, and later on we will call you for that purpose.

Dr. BRODE. Thank you very much.

The CHAIRMAN. If there are no further questions and no further business, the committee will adjourn until tomorrow morning at 10 o'clock.

(Whereupon, at 11:47 a.m., the committee adjourned, to reconvene at 10 a.m., Tuesday, February 17, 1959.)

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